Winter, 1961 [illegible] COLLEGE *$2.00*

The International Quarterly of the Society for the History of Technology

History of Technology: Soviet and Marxist Views

A. ZVORIKINE

DAVID JORAVSKY

C. St. C. Davison on "Transporting Sixty-Ton Statues in Early Assyria and Egypt"

Research Notes, Bibliographical Notes, and Reviews

Published by the

WAYNE STATE UNIVERSITY PRESS

for the

SOCIETY FOR THE HISTORY OF TECHNOLOGY

Editorial Board

Editor-in-Chief

Melvin Kranzberg
CASE INSTITUTE OF TECHNOLOGY

Editors

Richard H. Shryock	AMERICAN PHILOSOPHICAL SOCIETY
Lynn White, jr.	UNIVERSITY OF CALIFORNIA, LOS ANGELES

Advisory Editors

Homer G. Barnett	UNIVERSITY OF OREGON
Cyril E. Black	PRINCETON UNIVERSITY
Kenneth E. Boulding	UNIVERSITY OF MICHIGAN
I. Bernard Cohen	HARVARD UNIVERSITY
Carl W. Condit	NORTHWESTERN UNIVERSITY
L. Carrington Goodrich	COLUMBIA UNIVERSITY
Thomas P. Hughes	WASHINGTON AND LEE UNIVERSITY
John A. Kouwenhoven	BARNARD COLLEGE
Edward Lurie	WAYNE STATE UNIVERSITY
Robert P. Multhauf	SMITHSONIAN INSTITUTION
John U. Nef	UNIVERSITY OF CHICAGO
Derek J. de Solla Price	YALE UNIVERSITY
John B. Rae	HARVEY MUDD COLLEGE
David Riesman	HARVARD UNIVERSITY
Cyril Stanley Smith	UNIVERSITY OF CHICAGO
Reynold M. Wik	MILLS COLLEGE

PRICE TO NON-MEMBERS: $7.00 a year, $12.50 for two years, $18.00 for three years; add $.15 a year in Canada. $.35 a year abroad. Single numbers, $2.00. Membership dues include subscription (see inside back cover).

Published quarterly in Winter, Spring, Summer, and Fall by Wayne State University Press, Detroit 2, Michigan

Publication of this journal has been made possible by a grant from the Wilkie Foundation, Des Plaines, Illinois.

Editorial Office: The Society for the History of Technology, Room 311, Main Building, Case Institute of Technology, Cleveland 6, Ohio.

Copyright, 1961, Wayne State University Press.

Second class mail privileges authorized at Detroit, Michigan.

605
T 2 3c

TECHNOLOGY and CULTURE

volume II, no. 1 · winter 1961

Contents

ARTICLES

The History of Technology as a Science and a Branch of Learning: A Soviet View.....*A. Zvorikine* 1

The History of Technology in Soviet Russia and Marxist Doctrine.....*David Joravsky* 5

Transporting Sixty-Ton Statues in Early Assyria and Egypt *C. St. C. Davison* 11

RESEARCH NOTES

More on Medieval Pivoted Axles.....*A. Rupert Hall* 17

PERSONAL NOTES

An Appreciation of David Bernard Steinman (1886-1960).... *Sara Ruth Watson* 23

BIBLIOGRAPHICAL NOTES

A Biographical Bibliography of Electrical Engineers and Electrophysicists (Part I).....*Thomas James Higgins* 28

BOOK REVIEWS

The Story of Engineering by James Kip Finch....*R. J. Forbes* 33

A History of Mechanical Inventions by Abbott Payson Usher *Thomas M. Smith* 34

Rings Around the World: Man's Progress from Steam Engine to Satellite by Heinz Gartmann.....*Rudolf A. Clemen* 37

Der Weg aus der Tretmuhle by Franz Hendrichs.*Ladislao Reti* 41

History of the Milling Machine: A Study in Technical Development by Robert S. Woodbury...*Abbott Payson Usher* 43

Geschichte des technishen Zeichnens by Franz Maria Feldhaus *R. S. Hartenberg* 45

Die Uhr, von der Sonnenuhr zur Atomuhr by Anton Lubke *Derek J. de Solla Price* 49

Heavenly Clockwork: The Great Astronomical Clocks of

351918

Medieval China by Joseph Needham, Wang Ling, and Derek J. de Solla Price.....*L. Carrington Goodrich* 50
The House of the Double Axe: The Palace at Knossos by Agnes Carr Vaughan.....*L. Sprague de Camp* 53
Studies in Early Petroleum History and *More Studies in Early Petroleum History* by R. J. Forbes.....*Martin Levey* 55
Social Change in the Industrial Revolution: An Application of Theory to the British Cotton Industry, 1770-1840 by Neil J. Smelser .....*Bernard Barber* 57
Charleston's Sons of Liberty: A Study of the Artisans, 1763-1789 by Richard Walsh.....*Morrell Heald* 59
The American Civil Engineer by Daniel H. Calhoun.....*Sara Ruth Watson* 61
Colt: The Man, The Arms, The Company by James Mitchell *W. Eugene Hollon* 64
Yankee from Sweden: The Dream and the Reality in the Days of John Ericsson by Ruth White.....*Eugene S. Ferguson* 65
Nineteenth Century Glass: Its Genesis and Development by Albert Christian Revi.....*H. J. Haden* 68
Salt and Salt Shakers by Arthur G. Peterson...*Joseph Rossman* 71
Offices in the Sky by Earle Schultz and Walter Simmons.....*Carl W. Condit* 71
British Shipping by R. H. Thornton.....*L. R. Lampman* 73
The Impact of Air Power: National Security and World Politics edited by Eugene M. Emme.....*R. Sanders* 75
Studies in Company Finance: A Symposium on the Economic Analysis and Interpretation of British Company Accounts edited by Brian Tew and R. F. Henderson.....*Lawrence R. Chenault* 77
Industrialization in the Middle East by Kurt Grunwald and Joachim O. Ronall.....*S. K. Ghaswala* 79
Der Ingenieur und Seine Aufgaben in Neuen Wirtschafts-raumen.....*R. J. Forbes* 82
The Atom and the Energy Revolution by Norman Lansdell *B. C. Thompson* 83
Atomic Energy in the Soviet Union by Arnold Kramish....*Thomas P. Hughes* 85
Classical Mathematics: A Concise History of the Classical Era in Mathematics by Joseph Ehrenfried Hofmann.....*Mark Levinson* 86
The Scientific Revolution: Challenge and Promise edited by Gerald W. Elbers and Paul Duncan *George A. Gullette* 88
Creativity and Its Cultivation edited by Harold H. Anderson *Leonard Carmichael* 89

COMMUNICATIONS 93
ORGANIZATIONAL NOTES 96

The History of Technology as a Science and as a Branch of Learning: A Soviet View

A. ZVORIKINE*

BEFORE DISCUSSING the history of technology, we must deal with the concept of technology. When this concept first appeared it indicated art and craftsmanship, as the etymology of the word shows. With the development of production, the meaning of technology changed. During the period when handicraft production developed, technology began to denote procedure, methods, and formulas, that is, what is now called techniques. When production by machinery began to develop, technology came to refer primarily to the means of labor, that is, objects or groups of objects which man applied to the object of his labor and which served as a transmitter of his action to the object. Man uses mechanical, physical, and chemical properties of objects in order to achieve the desired result, as an instrument of his power.

Thus, the laws of nature are the objective basis of technology. Man learned the laws of nature through his experience, and began to apply and use them with the help of technology. Modern technology is the embodiment of the knowledge man has accumulated in his struggle to harness the forces of nature. Having grasped the laws of nature, and skilfully employing them, people can expand or limit the sphere of action of the laws and place the forces of nature in the service of man.

Using the achievements of natural science constitutes, however, only one aspect of technology. There is another important aspect: the social basis of its development.

* Professor Zvorikine is Editor-in-Chief of *Vestnik istorii mirovoi kultury* (*Review of the History of World Civilization*) and the author of more than one hundred books, pamphlets, and articles on the history, philosophy, and sociology of science and technology, with particular emphasis on mining. From 1949 to 1960 he was Assistant Editor-in-Chief of the *Great Soviet Encyclopedia*.

Technology was developed by man in the process of social production. Natural science only indicates possible solutions for technical problems, but by itself it can neither guide technology nor determine the scope or pace of its development. It is exclusively the economic laws of a given social system which in the long run determine the behavior of people and which guide the direction and pace of the progress of technology.

Proceeding from such a concept of technology, its connection with the laws of nature and the laws of society, we can formulate three features of the development of technology: (1) Though the development of technology is subject to the economic laws of each social formation, it does not, like other economic factors, end with the cessation of the laws of the formation. When in the process of revolution the old relations of production are broken up, technology remains and, subordinate to the economic laws of the new economic formation, continues to develop further, with added speed. (2) Contrary to the development of the economic basis in antagonistic societies, technology does not develop through leaps but by a gradual accumulation of elements of a new quality, while the elements of the old quality disappear. (3) Unlike social-economic phenomena, the development of technology is directly bound with the laws of natural science, while the social and economic phenomena are bound with the laws of natural science through the means of technology. Technology can actually develop only to the degree it corresponds to the laws of natural science, regardless of whether the laws are applied in technology unconsciously, as in the first stages of its development, or consciously, as at the present time.

The objective laws underlying the development of technology do not make the subjective factor in its progress less significant. The importance of the makers of new technology consists in the fact that, first of all, they employ the achievements of contemporary science and technology, providing designs and solutions most fully and correctly satisfying the needs of production and opening up prospects for further development of science and technology. Second, they are the first to appreciate the urgent technical needs of production. Besides the makers of new technology, an enormous part is played in its development by the working masses, who by their day-to-day labor help to bring about constant changes in

technology and advance from their ranks the inventors, engineers, and scientists who effect the great changes.

Technology, like science, is international, but it is created by individual peoples. Each nation makes its contribution to the development of engineering, depending on concrete historical and other conditions. For example, one cannot deal with the development of heat engineering without mentioning works by Newcomen, Polzunov, James Watt, Sadi Carnot, and others. One cannot discuss the development of electrical engineering and pass by such names as Faraday, Marcel Deprez, Edison, and Dalivo-Dobrovolsky, or tell the story of aviation without mentioning Lilienthal, Mozhaisky, and the Wright brothers.

After singling out the nature of engineering, revealing its ties with natural science and social and economic conditions, and showing the course followed by people in their creative activity, it is possible to define the history of technology as a science. The history of technology is the science dealing with the development of means of labor in a system of social production. From the viewpoint of natural science, the history of technology must describe how man mastered the laws of nature in an increasing degree, ensuring a more profound and multi-faceted use and application of natural substances and power sources. From the social point of view, the history of technology should reveal the motive social forces and social and economic conditions for the development of technology. The influence of technology on the development of society must be shown, as well as the part played by the makers of new technology among various nations.

Outstanding workers in culture, science, and technology have emphasized the exceptional importance of teaching the history of technology. Maxim Gorky wrote in 1928: "Another most important subject ought to be introduced in the schools: the history of labor, the wonderful and tragic story of man's fight against nature, the story of his discoveries and inventions, his victory and triumph over the blind natural forces." Seeing the disregard of the historical principle as the chief shortcoming in the teaching of the exact sciences, the French scientist Paul Langevin pointed out that this omission resulted in an incorrect view among students that science was a thing completed once and for all. The history of technology as a subject for study should broaden the students'

outlook, reveal the laws of technical development, and show the triumph of human thought in its fight against the forces of nature.

REFERENCES

(Editor's Note: All the titles in the following bibliography have been translated from the Russian. It should be noted that, according to the orthography employed by the Library of Congress, Zvorikine would be spelled "Zvorykin.")

[1] A. A. Zvorikine, "Main Problems of Teaching and Studying the Theory of Technology," in *History of Technology*, Fasc. I (Moscow, 1934), pp. 5-28.

[2] A. A. Zvorikine, "Studying and Teaching the History of Technology," in newspaper *Tekhnika*, September 18, September 27, October 15, 1934.

[3] A. A. Zvorikine, "Research and Pedagogical Work in the Field of History of Technology," *Vysshaya tekhnicheskaya shkola* (*Higher Technical School*), No. 5 (1935), pp. 87-97.

[4] A. A. Zvorikine, "History of Mining Engineering," Lectures 1-5, Public University of Pressional Improvement (Moscow, 1940). Cf. Ch. I: "The Aims, Subject Matter and Method of the History of Technology."

[5] A. A. Zvorikine, Papers Read at the Conference on Instruction in the History of Technology (February 1949):

1. "The History of Technology in the System of Training Soviet Engineers";
2. "Main Principles and Curriculum of Instruction in the History of Technology in Higher School," *Vestnik Vysshei Shkoly*, No. 4 (1949), pp. 31-34.

[6] A. A. Zvorikine, "Certain Problems in the History of Technology," *Voprosy Filosofii* (*Problems of Philosophy*), No. 6 (1953), pp. 32-45.

[7] A. A. Zvorikine, "Technology" in the *Great Soviet Encyclopedia* (2nd edition, 1956), Vol. 42, pp. 382-386.

[8] A. A. Zvorikine, "Academic Program of the Course in the History of Technology for Higher Technical Educational Establishments," *Soviet Science* (2nd edn., 1958), p. 14.

[9] A. A. Zvorikine, "Certain Problems of the Periodization of the History of Natural Science and Technology," *Voprosy istorii yestestvoznaniya i tekhniki* (*Problems in the History of Natural Science and Technology*), Fasc. 4 (1957), pp. 153-162.

The History of Technology in Soviet Russia and Marxist Doctrine

DAVID JORAVSKY*

THE HISTORY OF TECHNOLOGY has had a fourfold attraction to Soviet Marxists. It is of central importance both to the general philosophy and to the theory of history by which they defend their political program; it has long been used in the ideological education of specialists; and in the past few years study of the subject has been urged, as Professor Zvorikine points out in the preceding article, as a method of humanizing technical specialists, of saving them from the stultifying narrowness of their competence. The first two aspects of this attraction stem directly from Marx and have been felt by his spiritual descendants on both sides of the Russian frontier. To understand the peculiarities of *Soviet* Marxist work in the history of technology, one must see it in its specifically Soviet context.

During the 'twenties Soviet Marxists published only occasional works on the subject; the center of research and publication in the field was a Commission on the History of Knowledge at the Academy of Sciences, the source of a modest number of non-Marxist publications. Then came the first Five Year Plan, in this as in many other fields a more profound revolution than the more famous one of 1917. In November, 1929 the Central Committee of the Communist Party decreed a course in "the Marxist history of technology" as one way to educate "new, proletarian specialists, on whom the Soviet regime could rely wholly and completely in its grand work at the construction of socialism, who could satisfy the growing demand [for specialists], and could replace those elements among the specialists that are hostile to us. . . ."[1] Pro-

* Dr. Joravsky is Assistant Professor of History at Brown University. He has published articles in *Isis* and the *Journal of the History of Ideas* on Soviet Marxism and the philosophy of natural science.

fessor Zvorikine was the chief member of a special Commission in Moscow charged with drawing up such a course. Scholarly research and publication were still centered at the Academy of Sciences in Leningrad, where the Commission on the History of Knowledge was transformed into a full-fledged Institute of the History of Science and Technology, headed by the famous Communist theorist, N. I. Bukharin. Some friction resulted; the group in Moscow, concerned more with elementary ideological indoctrination than with advanced research, resented the somewhat patronizing attitude of the Leningraders. In 1937, when Bukharin was arrested as an "enemy of the people," the Institute and its publications died with him.[2] But research and publication in the history of science and technology revived, spurred on this time by the Party's demand for proof that Russian scientific and technical genius was at least equal to anything that foreign nations could boast.[3] The truculent claims of priority that resulted caught the attention of the outside world, which failed for the most part to note that much solid work was done, largely at a new Institute established within the Academy of Sciences in 1945. In the past six or seven years there has been a refreshing decline in the nationalistic spirit of this Institute's voluminous publications, but programmatic statements continue to emphasize the inculcation of unswerving devotion to the Soviet homeland as the principal function of Soviet historians of science and technology. This is especially true of programs for teaching the subject, an area in which Professor Zvorikine is still a leading authority. He seems to have put the whole matter aside when he wrote the article printed here, but items five and six of his bibliography show that he is far from abandoning his emphasis on the history of technology as a means of ideological indoctrination.

With this background in mind it is not hard to understand why Soviet scholars "avoid coming out with works on problems of the methodology of the history of science and technology, with research into the fundamental theoretical problems of this field of scholarship."[4] To be sure, they have published quite a few articles on such subjects as definitions of the term *tekhnika* (technique or technology), or periodizations of the history of science and technology, but, like Professor Zvorikine in his present article, they have tended toward brevity and indefiniteness on crucial points.

Most have concentrated their energy on producing impressive factual studies, failing, however, to use their rich material to shed light on the basic questions raised by Marxism. Both deficiencies are a pity, especially since Marxist theory is famous for its provocative challenges to historians.[5]

As Professor Zvorikine makes clear, Soviet Marxist historians of science and technology are usually far from the one-sided economic determinism that Hessen made famous in 1931.[6] They usually recognize the importance in technical development of individual genius, of theoretical natural science, of national conditions, and of the autonomous logic of developing instruments and processes. But "in the long run" or "the last analysis," these factors are of secondary importance. "It is," Professor Zvorikine tells us, "exclusively the economic laws of a given social system which in the long run determine the behavior of people, guide the direction and pace of the progress of technology." Thus we come to the familiar tension within Marxist historical theory. It tends toward economic determinism and at the same time toward the multiple-factor, the seamless-web view of history. What is meant by Engels' assertion that there is "interaction [of various factors] on the basis of economic necessity, which *ultimately* always asserts itself."?[7] The question is particularly acute for the Marxist historian of technology, in view of Engels' definition of economic necessity:

> What we understand by the economic conditions which we regard as the determining basis of the history of society are the methods by which human beings in a given society produce their means of subsistence and exchange the products among themselves (in so far as division of labor exists). Thus the *entire technique* of production and transport is here included.[8]

Thus technology is a, or even *the*, crucial element of the economic conditions that determine the whole of social development; yet the development of technology is itself determined by "the economic laws of a given social system."

Whether this paradox is to be a meaningless shuffle of terms or an endlessly provocative challenge to theoretical analysis and historical research depends on the attitude of Soviet Marxists toward their basic theory. Predominantly reverential and uncritical toward it, they have been unable to prove it in the best sense of the word "prove," that is, to try the theory, to see where it is right and

where wrong. Theoretical writings have tended to be sterile repetitions of general formulas, while historical research has tended to be the compilation of factual material with little regard to the theoretical problems raised by Marxism. One hopes that Soviet historians of science and technology will prove this to be an unfair judgment. The present writer does not pretend to know all their work, and even if he has made accurate inferences from the fraction that he is familiar with, there are grounds for expecting improvements.

Similarly with the problem of nationality. Russian scholars have been returning to the international breadth for which they were once famous, and, in doing so, they have come to the threshold of major questions which they have hesitated to cross. Certainly it helps the cause of international friendship and adds to scholarly accuracy when historians of science and technology are careful to give credit to the contributions of other nations than their own, as Soviet scholars have once again been doing. We should follow their example. American textbooks should stop giving children the impression that the Wright brothers invented the airplane singlehandedly. The *History of Technology* edited by Singer should not declare that the use of a steam engine in 1776 to blow a furnace in Shropshire was the first time that the steam engine was used for purposes other than pumping water.[9] Ten years previously Polzunov's steam engine blew a furnace in Barnaul. Factual precision and international good will require that we give up our supercilious neglect of the Russians, as they have given up their nationalistic truculence toward us. But meticulous courtesy is not the only end of scholarship in these matters. Polzunov is worth mentioning not just to show our respect for the Russians, but even more to demonstrate the influence of national conditions on the development of technology. Polzunov's steam engine blew a furnace from August to November, 1766; when the boiler sprang a leak, the whole project was abandoned. It faded from the memory of the Russians themselves until historians discovered records of it about sixty years ago.[10]

Soviet historians of technology would probably win a wider international audience for their work, if they would be less concerned to prove that Polzunov ranks with Watt or Carnot in the development of heat engineering and more concerned to discover

the pattern of technological development in a late-blooming industrial nation. To disentangle technological, socio-economic, and political causes and effects in the long duration of Russian backwardness, in the onset of rapid industrialization toward the end of the nineteenth century, and in its stormy completion under the unique conditions of Soviet socialism would be to make contributions of inestimable value. Perhaps it might even be possible to pinpoint some other elements of national character than mechanical aptitude—didn't we know already that all nations have the *aptitude*? —and thus bring light to one of the darkest corners of history. To accomplish such things Soviet historians would have to use their theoretical heritage in a more venturesome, a more critical spirit than they have hitherto.

Other readers probably shared this one's double pleasure in reading Professor Zvorikine's article. It betokens a growing cultural exchange, stimulating the hope that the dreadful union of twentieth-century military technology with sixteenth-century international politics may yet be overcome. The content of the article is cause for an additional pleasure, probably surprising to most readers: how like it is to much of "our own" thought on the subject, how unlike the stereotyped Western view of Soviet writing in this field! (Soviet readers would probably get a similar double pleasure if they were to find a comparable article by, say, Lewis Mumford in *Voprosy istorii estestvoznaniia i tekhniki*.) Zvorikine's calm, common-sense observations tempt one to hope that Soviet-American scholarly exchanges may leave behind not only abusive polemics but even evasive expressions of a vague benevolence. Ceremonious, bland compliments do show good will, but a disdainful good will that is barely preferable to enmity. May one hope that Western historians of science and technology will begin to pay serious attention to Soviet work, as their Soviet counterparts have to theirs? Necessarily, then, one must also hope that Soviet historians of science and technology will learn to accept frank criticism as a friendly tribute to their work rather than a spiteful derogation of it.

REFERENCES

[1] *Kommunisticheskaia Partiia Sovetskogo Soiuza v rezoliutsiiakh i resheniiakh s'ezdov, konferentsii, i plenumov Ts. K.* (7th ed.; Moscow, 1953), Vol. II, pp. 513-514.

[2] See A. Zvorikine, "Likvidirovat' do kontsa posledstviia trotskistsko-bukharinskogo vreditel'stva na fronte istorii nauki i tekhniki," *Vestnik Akademii Nauk SSSR*, No. 4-5 (1937), pp. 14-24.

[3] See, e. g., A. Zvorikine, "O sovetskom prioritete v nauke," *Bol'shevik*, No. 22 (1948), pp. 23-42.

[4] N. A. Figurovskii, "Istoriia estestvoznaniia i tekhniki v SSSR za 40 let," *Voprosy istorii estestvoznaniia i tekhniki, vypusk 6* (1958), p. 11.

[5] For representative works of the 'thirties, see *Arkhiv istorii nauki i tekhniki*. For the post-war period, see *Trudy Instituta istorii estestvoznaniia i tekniki*, and *Voprosy istorii estestvoznaniia i tekhniki*.

[6] B. Hessen, "The Social and Economic Roots of Newton's 'Principia,'" in *Science at the Crossroads* (London, 1931). Also in separate printings.

[7] K. Marx and F. Engels, *Correspondence, 1846-1895* (New York, 1936), p. 517.

[8] *Ibid.*, p. 516.

[9] C. Singer (ed.), *A History of Technology* (New York-London, 1958), Vol. IV, p. 104.

[10] For a convenient account, with a brief bibliography, see A. A. Zvorikine (ed.), *Biograficheskii slovar' deiatelei estestvoznaniia i tekhniki* (Moscow, 1959), Vol. II, pp. 135-136.

Transporting Sixty-Ton Statues in Early Assyria and Egypt

C. ST. C. DAVISON*

IN THESE DAYS of bulldozers, heavy trucks, and huge cranes which easily transport and lift building materials, we often marvel at how the ancients moved stone blocks weighing over sixty tons for building pyramids and other structures, for they had little else to assist them in this task than muscle and brawn, aided by strong ropes and simple wooden frames. The earliest—and most difficult—method of transporting large blocks of building stone was by dragging them over the ground. Eventually the sledge was utilized for this purpose, followed by the wheeled wagon. However, historians have seemed unwilling to accept this simple evolution in transportation for which there is ample and incontrovertible evidence; they reason that rollers (loose) *must* have preceded the wheel, and they have eagerly looked for proof to bear this out.

At Nineveh between 1845-51, Sir A. H. Layard discovered some important bas-reliefs (Sculptures 124820, 124822, and 124823 in the Nineveh Room of the British Museum) which seemed to provide evidence as to how King Sennacherib (705-681 B. C.) had moved his huge sculptures from the quarries at Mosul, down the river in boats for a stretch of 20 miles and then on sledges over the Kouyunjik Mounds to the palace and library.[1] Layard said: "The only mechanical powers possessed by the ancients were ropes, rollers and levers." This dictum became firmly established among archaeologists from then on; it is still repeated in many scholarly and widely read historical works,[2] and illustrations showing how the Trojan horse was drawn on a sledge with a series of long, loose, wooden rollers underneath are a commonplace in text-

* Dr. Davison is in charge of the following sections at the Science Museum in London: Weighing and Measuring, Internal-Combustion Engines, Mechanical Power Transmission, and Roads and Bridges. He is the author of *The History of Steam Road Vehicles* and *Historic Books on Machines.*

books. Despite the wide acceptance of this notion, there is absolutely no foundation for Layard's surmise about rollers.

Transporting a Colossus to King Sennacherib's Palace

The bas-reliefs (Figs. 1 and 2) show an Assyrian colossus (similar to that shown in Fig. 3) being carried from the river to the palace (seventh century B. C.). Workmen can be seen (Fig. 1) placing small pieces of wood in front of the sledge, either in order to reduce friction between the sledge and the ground or to raise the bottom above the sharp rocks. The form and function of these pieces of wood as interpreted by archaeologists require close examination. Layard referred to them as " rollers." In support of Sir Henry's theory it is claimed that the sculptors lacked knowledge of perspective; hence they showed the " rollers " under the sledge with their long axes in the direction of motion.[3] Two questions come to mind which cast doubt upon this explanation: since the Assyrian artists had the skill correctly to draw such minute details as the strands of the ropes, the engravings on the hafts of the overseers' swords, and the axles on the carts, can it not justifiably be assumed that the pieces of wood were also correctly drawn? Further, since they could depict an end-view of an axle, can one doubt that they could also draw the end-view of the so-called " rollers "?

In fact, the " rollers " are portrayed as being neither round nor straight; they clearly are trimmed tree-branches, (Fig. 1, lower right), and it is obvious that they are far from being cylindrical rollers. Indeed, should a number of rollers have been placed under the sledge, they would have had to be exactly parallel to each other; otherwise they would have taken their own different directions of motion and collided. When this happens with two rollers, they jam because they rotate in opposite directions where they touch at their peripheries. The ground also would have had to be levelled with an accuracy which it was impossible for the ancients to achieve.

Despite the arguments militating against the employment of rollers by the ancients, archaeologists have searched for sledge-rollers to prove that they were thus employed. They found only a small " roller " at Deir el-Bahri near the pyramids. It is approximately nine inches long and of a diameter varying from about

two inches at the ends to about three inches in the middle. This specimen is now on exhibition at the British Museum and is dated about 2100 B. C.[4] The only justification for claiming that it had been utilized for carrying building-stones is that it bears marks like those caused by heavy weights. Yet it could equally have served as a fulcrum for an oscillating beam or lever. In spite of the inadequate evidence this "roller" has been accepted as additional "proof" that rollers were employed by stonemasons in transporting colossal weights.[5]

In his book Layard explained how he transported the winged bulls and lions now in the British Museum from the ruins to the banks of the Tigris, stating that this was done on a four-wheeled vehicle with very strong roller-like wheels (about 4 ft. in diameter by 3 ft. wide) pulled by 300 men. This, he maintained, was proof enough that rollers were employed under sledges. He obviously failed to see that the action of the rollers on the cart-axle was entirely different from that of axleless "rollers" placed haphazardly between rough ground and a sledge. One can see (Fig. 4) the large wheel felloes on the Assyrian chariots of about 850 B. C.; it stands to reason that the wider the felloes of the wheels, the less likelihood there was for them to sink into soft earth or sand. This representation of an early scene of chariots and a bridge of boats also proves that the Assyrians were capable of making an orthographic drawing *par excellence*, even though they were unacquainted with the laws of perspective.

Herodotus, the historian (ca. 484-424 B. C.), said that rollers were employed for transporting boats. To this day we have a device for winching up boats from the sea on top of a series of wooden rollers, each one with an axle fitting into a hole in a stationary framework. One may, therefore, accept the existence of Herodotus' rollers. Moreover, Vitruvius, Roman architect, engineer, and superintendent of machines of war, described how large stone columns for a building had each been fitted with an axle and framework; they were then drawn like wagons to the site of a new building (ca. 25 B. C.).[6] But the combination of loose rollers and sledges has no counterpart in modern technology—another fact which serves to cast doubt on their employment by the ancients.

Transport of a Colossus in Ancient Egypt

It is clear from Sir A. H. Layard's words that a different method was employed in Egypt for transporting enormous weights: "The absence of levers and rollers is remarkable, as the Egyptians must have been well acquainted with the use of both, and no doubt employed them for heavy weights." [7] Credit must be given to Sir Henry for stating that rollers were not found in Egypt, but the statement indicates that he strongly believed the Assyrian tree-branches to be rollers. It also shows that his knowledge of the kinematics of rollers was insufficient.

In referring to the painting (Fig. 5) in the Egyptian grotto at El Bersheh (XII dynasty) where the transport of an enormous statue is portrayed, Layard wrote: "On the statue as in the Assyrian bas-reliefs stands an officer who claps his hands in measure-time to regulate the motion of the men and from the pedestal another pours some liquid, probably grease, on the ground to facilitate the progress of the sledge, which would scarcely be needed were rollers used." Such an unscientific conclusion as this can only be rivalled by one made in 1930 by Clarke and Engelbach: "It is incredible that Assyria should have known the roller and not Egypt. A nation which used blocks and which never deduced the value of a roller for reducing friction from such homely occurrences as slipping on a walking-stick left on the floor would be subhuman in intellect, which the Egyptians were not." [8] Have the authors never slipped on a banana skin? Sliding objects sometimes can have less friction than rolling ones, and there would have been no advantage gained with rollers.

Did the Egyptians Invent Lubricated Sliding Bearings?

Upon examination of the ancient Egyptian painting (ca. 1880 B. C.) referred to by Layard (Fig. 5), we see 172 men pulling a statue weighing some sixty tons and a man pouring a liquid on the ground in front of the sledge. If the ground were earthen it would become more slippery, but if it were soft, flat, and sandy, as it is in Egypt, the liquid would filter through the sandy soil with no effect at all. Should, however, large flat pieces of wood, like the one carried by the three men on their shoulders, be placed under

Fig. 1. Fragment of a bas-relief showing gangs of slaves pulling a sledge. British Museum, No. 124822.
(Reproduced by permission of the Trustees of the British Museum.)

Fig. 2. Sledge and colossus which the slaves in Fig. 1 are pulling. British Museum, No. 124823.

Fig. 3. Colossal winged human-headed lion of Ashur-nasir-pal II, King of Assyria, 883-859 B.C. From Nimrud (Calab). British Museum, No. 118801. (Reproduced by permission of the Trustees of the British Museum.)

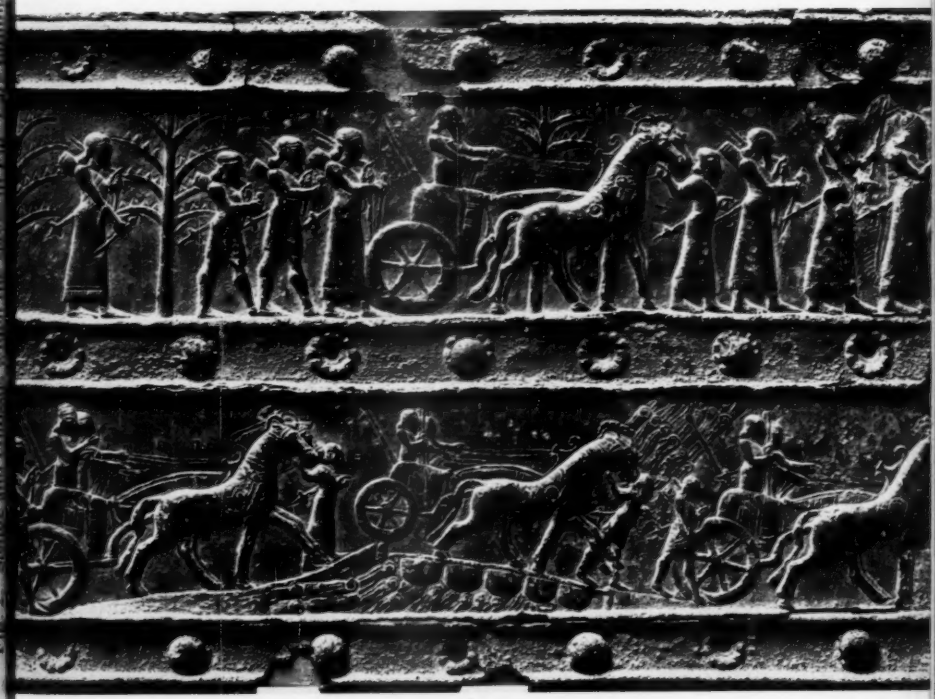

Fig. 4. Portion of an embossed bronze band from the palace gate of Shalmaneser III, King of Assyria, 859-824 B.C. British Museum, Neg. 4F19, as shown in *Guide to the Babylonian and Assyrian Antiquities*, 1922, p. 52. (Reproduced by permission of the Trustees of the British Museum.)

Fig. 2. Sledge and colossus which the slaves in Fig. 1 are pulling. British Museum, No. 124823.

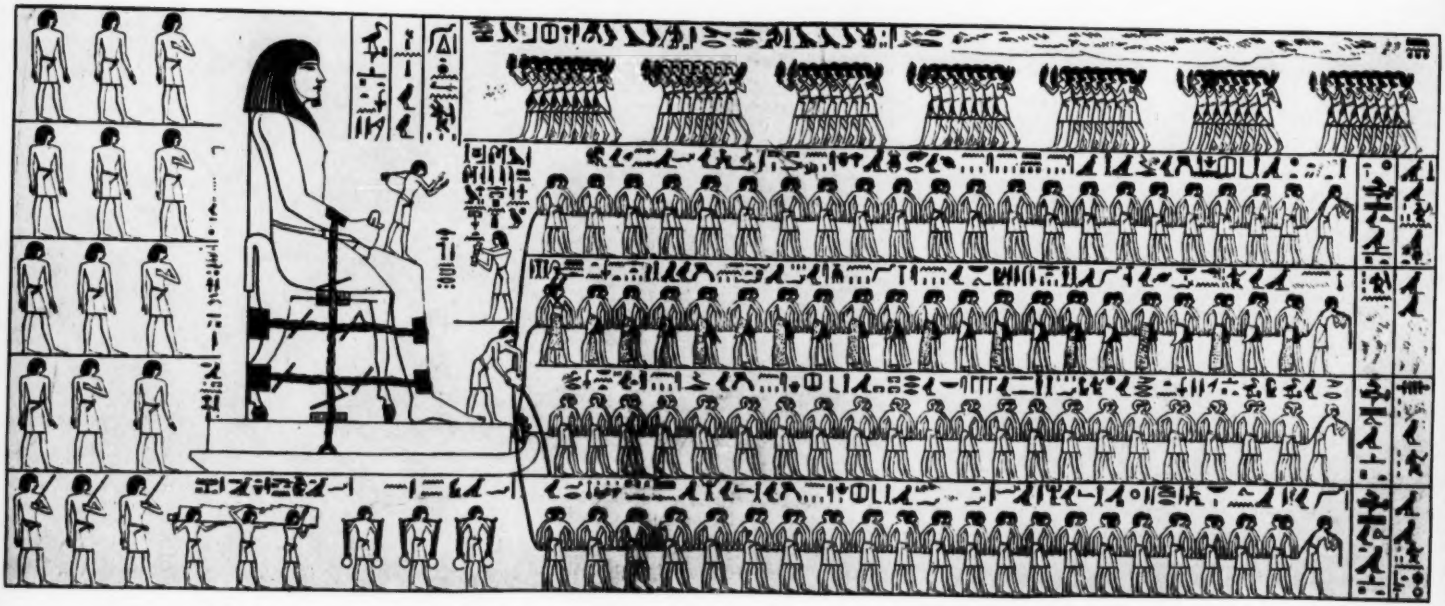

Fig. 5. Transporting an Egyptian colossus, ca. 1880 B.C. From a drawing in a grotto at El Bersheh.
(Reproduced from Sir A. H. Layard, *Discoveries in Nineveh and Babylon.*)

the sledge and covered with oil, the work of transporting the statue would become easier. Although the Egyptians are known to have employed 100,000 men each year to transport heavy stone blocks,[9] it was obviously to their advantage to make this operation as efficient as possible, if only with the sole object of having fewer mouths to feed. Although the illustration does not show the flat boards being placed under the sledge, the following calculation leads one to conclude that this is the reason why the board is shown in the picture and why the artist showed likewise three men going before the board and carrying six pots of lubricant. Assuming that:

(a) The alabaster colossus and sledge weighed[10] about 60 tons (1 ton = 2240 lb.)

(b) Each board measured about 192 in. x 18 in. (from the drawing)

(If these boards were placed end-to-end under each side of the sledge there would be a bearing-pressure of about 20 lb. per square inch, this being a pressure employed on modern tracked vehicles.)

(c) The coefficient of sliding friction (μ) was 0.16 for hard wood on hard wood well lubricated with oil at 20 lb. per square inch bearing-pressure[11]

(d) The average pull of a man was 120 lb.

Then, the number of men required to pull the sledge can be arrived at by the following equation:

$$\text{Frictional force} = \mu R, \text{ Thus we obtain:}$$

$$\text{Number of men} = \frac{0.16 \times 60 \times 2240}{120} = 179.$$

The number of men arrived at, i. e., 179, is very close to the 172 men pulling the sledge as portrayed in the mural painting.

If the boards had not been lubricated it would have taken about three times as many men to pull the sledge. The economic value of such a method of transport becomes obvious.

It is obvious, too, that tree-branches placed under a sledge on anything but a very hard ground would sink below the surface and would remain immovable both in translation and rotation. Also, flat pieces of wood, if made of sufficient area, would prevent a sledge from sinking in the sand. Some caterpiller-tracks on tanks

in World War II, which the author helped to design whilst at the Admiralty, prevented the tanks from sinking into the sand when the ground-pressure was about 20 lb. per square inch; this is about the same pressure as would exist on the flat boards under the Egyptian sledge. It thus appears most likely that lubricated boards were employed, and we again find the beginnings of a modern technique, namely, lubricated flat machine-surfaces.

REFERENCES

[1] Sir A. H. Layard, *Nineveh and Babylon* (London, 1867).

[2] Charles Singer, E. J. Holmyard, and A. R. Hall, editors, *A History of Technology*, Vol. I (Oxford, 1954), pp. 452, 470, 710; I. E. S. Edwards, *The Pyramids of Egypt* (Penguin Books, 1955), pp. 216, 229.

[3] S. M. Cole, "Land Transport Without Wheels: Roads and Bridges," in Singer *et al.*, ed., *A History of Technology*, Vol. I, p. 710.

[4] The British Museum description of this "roller" is as follows: "Exhibit No. 43229. Wooden roller for moving building-stones. The ends of these rollers are generally pointed. From Deir el-Bahri, XI Dynasty, c. 2100 B.C. Presented by the Egyptian Exploration Fund, 1906."

[5] S. Clarke and R. Engelbach, *Ancient Masonry in Egypt* (London, 1930) pp. 89, 90.

[6] Marcus Vitruvius Pollio, *De Architectura*, translated by M. H. Morgan (Cambridge, Mass., 1914), p. 288.

[7] Sir A. H. Layard, *Discoveries in Nineveh and Babylon* (London, 1853), p. 115.

[8] Clarke and Engelbach, *op. cit.*, pp. 89, 90.

[9] Edwards, *op. cit.*, pp. 216, 229.

[10] Although the reader may doubt the existence of such a heavy piece of alabaster, the Keeper of the Egyptology Section of the British Museum informs me that there was a description beside the painting which stated that the material was alabaster. The description is quoted in Edwards, *op. cit.*, p. 216. The painting and description were later destroyed in an earthquake.

[11] E. Oberg and F. D. Jones, editors. *Machinery Handbook* (New York, 1940), p. 507.

Research Notes

MORE ON MEDIEVAL PIVOTED AXLES

A. RUPERT HALL*

THE DOUBTS of Dr. Marjorie Nice Boyer concerning the use of a front-wheel turning-train on medieval wagons can, I believe, be settled by one of my favorite medieval authors, Guido da Vigevano.[1] She writes (*Technology and Culture*, Vol. I, No. 2 [Spring 1960], p. 135), "Illustrations do not with certainty prove evidence for the pivoted front axle before the end, and expense accounts not before the middle, of the fourteenth century." Guido provides definite evidence for it, as a commonplace, in 1335.

In that year, by his own statement, to which as far as I know no one has ever taken exception, Guido da Vigevano completed his *Texaurus Regis franciae acquisicionis terrae sanctae de ultra mare nec non sanitatis corporis eius et vitae ipsius prologacionis ac etiam cum custodia propter venenum.* I have already published a brief account of this text, and hope to print a complete study of it in the near future.[2] It is one of the most interesting technological manuscripts of the Middle Ages. Two manuscripts exist; one is in the Bibliothèque Nationale (Latin no. 11015), the other which I have also used is now the property of Mr. Laurence Witten of New Haven, Connecticut. The latter is a variant and in some respects superior text, *copulatus* (according to the colophon) in Cyprus by Martin of Aachen in 1375.

Guido's work contains many technological curiosities. He was well aware of the usefulness of interchangeable parts and of the importance, for portability on a Crusade, of assembling large structures from small members. He described a paddle-wheel boat, an

* Dr. Hall is the author of *The Scientific Revolution: 1500-1800* and was one of the editors of the five-volume Singer, *History of Technology*. He is now with the Division of Medical History of the Medical Center at the University of California (Los Angeles).

inflatable life-belt, a short proto-railway line, the four right-angle crank, the engineering of a turret windmill, and so on, but for the moment we are concerned with his two wooden "tanks" or fighting-cars (See figures). From these, obviously, the well-known figure first used in Roberto Valturio's *De re militari* (Verona, 1472) was copied, along with other devices lifted directly or indirectly from the same source.

It is needless to reproduce now the whole of chapters XI and XII of the *Texaurus*, in which these exhilarating vehicles are described. The principles are plain enough from the figures, despite their sad lack of perspective and draftsmanship. Even a quick glance will indicate that the identical front axles are intended to pivot. Obviously a vehicle propelled internally *could* only be steered by pivoting one or the other of the axles. One might say that the idea of a turning-train is an essential preliminary to that of a self-propelled vehicle—or a necessary consequence of it.

Unfortunately, Guido does not describe the assembly of the fore-train in language I can understand, nor is the arrangement fully clear from the figure. It is impossible to tell whether the hairpin-like object (in both sketches) is intended as an oversize split-pin serving as a pivot, or an undersized pair of shafts. Moreover, the iron bearings supporting the crank are nonsensically attached (apparently) to the fixed body of the car (Fig. 1). I say "nonsensically" because the purport of this sentence from Chapter XI is crystal-clear:

> Et ut carrum ducetur recte per viam et revolvatur cum fuerit necesse illud quod ducitur ante per boves volvatur retro et uno homo vel duo teneat de retro tumonem (?)[3] in manu et volvatur carrum quando voluerit. Et credo quod forte melius volvetur carrum ducendo cum duobus tumonibus ante et uno equo quando carrum debuerit duci per stratas. Sed cum quis fuerit in opere providebit pro meliore.
>
> ["And so that the car may be steered along the road and turned around when necessary, that which is drawn in front by oxen is swung behind; and one man (or two) holds the reversed shaft in his hand, and the car is turned around when he wishes. And I believe that the car may be turned around far better by drawing it with two shafts in front and a single horse, whenever the car is to be brought through streets. But when anyone takes his job on he will provide what is best."]

Substantially the same is said of the second car in Chapter XII.

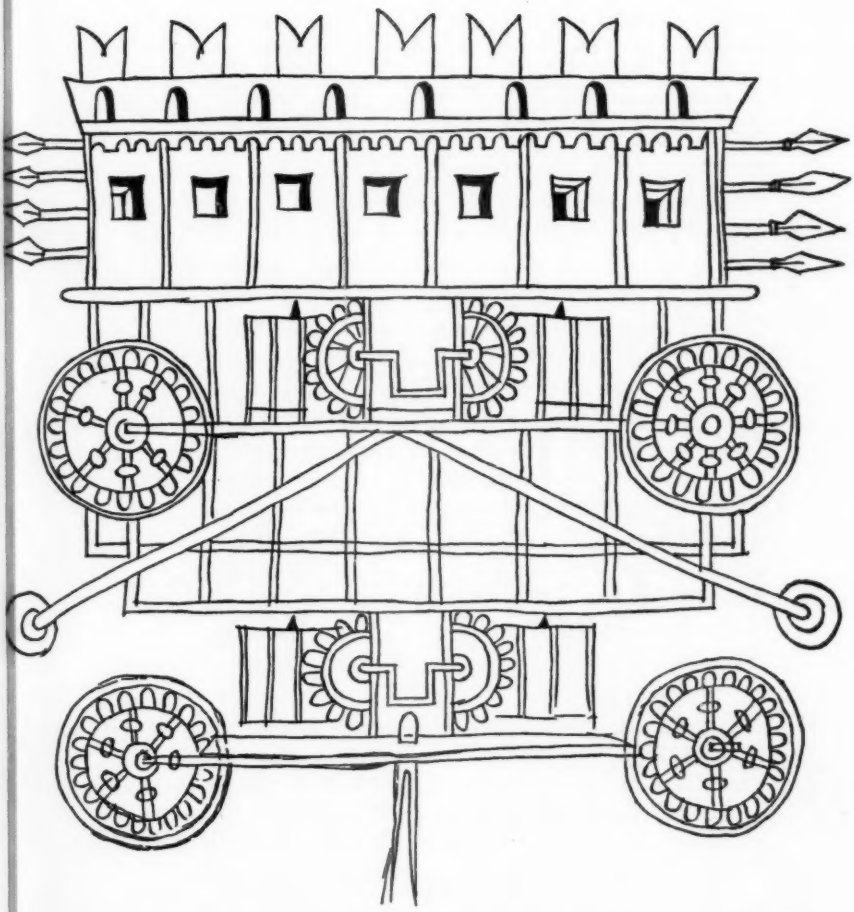

Fig. 1. Crank-propelled fighting car, from the MS. of Guido's *Texaurus* now in the possession of Mr. Lawrence Witten.

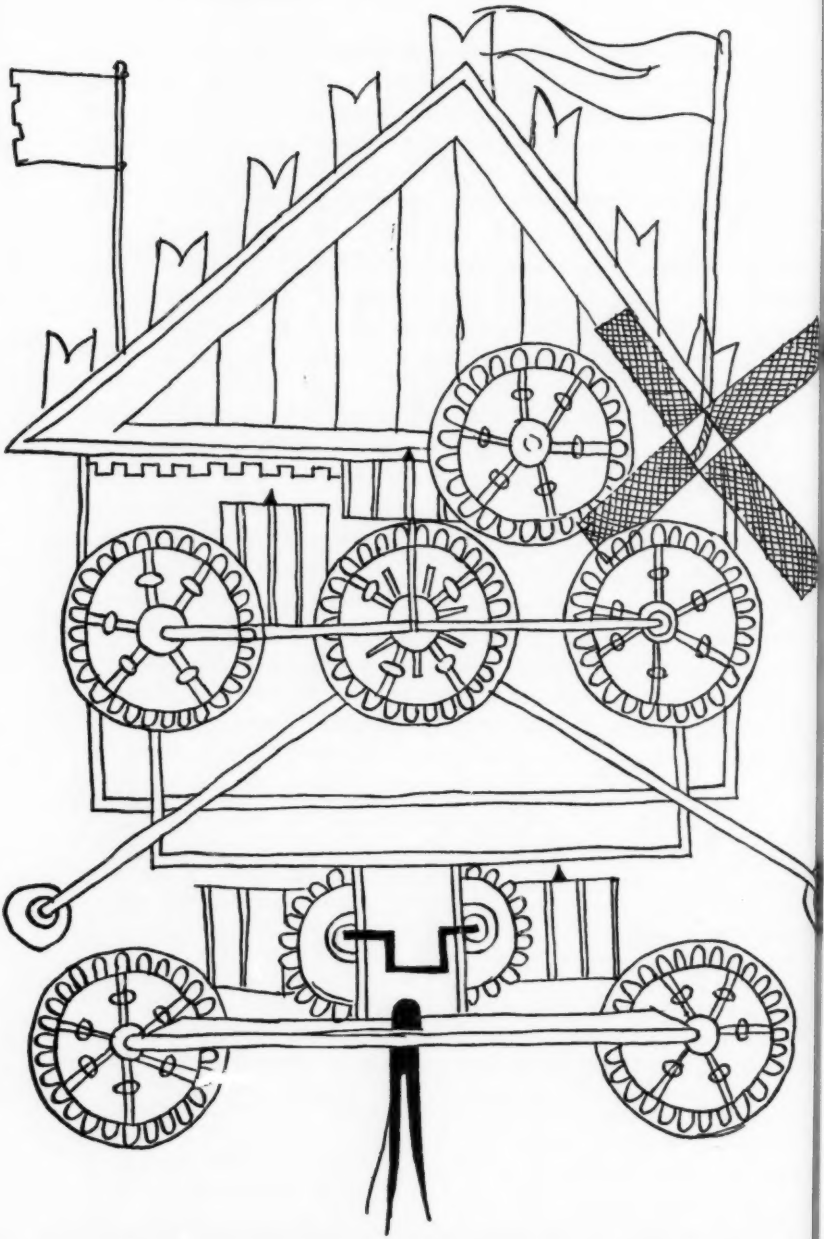

Fig. 2. Wind- and crank-propelled fighting-car, from Guido's *Texaurus*

What is intended is logical, if impracticable. For active service, the single shaft of an ox-team is swung around and becomes a tiller in the hands of a man inside the car, who steers the front wheels. In peacetime parades, however, Guido thinks it best to give up the self-propelled scheme and use a horse in a pair of shafts. He was a physician, not an engineer, and he did not work out all the details of his schemes thoroughly. He often remarks that if it is not clear how something is to be put together, the master millwright will work out a way. So he did not predate Ackerman—though his solution of the problem of control was not so very different from that of the first makers of horseless carriages less than a century ago.

If Guido did not invent the pivoted front axle—on which, by the way, the wheels turn freely, each being connected by gears to the front-wheel-drive crank—it was obviously already in use by the wainwright. His casualness in referring to it, and failure to describe it in detail, induce me to prefer the latter hypothesis. There is no reason to believe that Guido was a fourteenth century Edison; it seems rather that the various devices he employed were already fairly familiar. His originality lay in putting them together for new uses. For instance, the side-struts on the windmill car (Fig. 2)—foolishly copied in the other figure though they are not required by the text—are clearly derived from actual windmills. Possibly the problem of steering would never have struck him, if he had not been aware that in turning corners a wagon's front axle is inclined at an angle to its normal position. In battle, the straight run of a few such monsters would have been pretty effective, and out of battle they could have been maneuvered by animals like other vehicles with two fixed axles—if they had two fixed axles. The very fact that Guido contemplated the problem of steering—and solved it by a pivoted front axle—is, at least, a very strong presumption that four-wheeled wagons were already fitted with them.[4]

REFERENCES

[1] There is no major publication on Guido's technology, though one is in preparation. There is a brief and partially misleading account in George Sarton, *Introduction to the History of Science*, Vol. III, Part 1, pp. 846-7. The best biography is that of Elie Berger, *Journal des Savants*, Vol. XII (Paris, 1914), pp. 5-14. His *Anatomy* has been printed by Ernst Wickersheimer.

[2] A. R. Hall, "The Military Inventions of Guido da Vigevano," *Actes du VIII^e Congrès International d'Histoire des Sciences* (1957), pp. 966-69.

[3] I have interpreted *tumo* (if I have read the word aright) as a variant of *temo* (pole, shaft), which seems to fit the sense.

[4] My colleague Professor Lynn White has kindly drawn my attention to a mention in *Speculum*, Vol. XXXIII (1958), p. 250, n. 3, of ships and castles in fourteenth-century pageant processions made to run on wheels by men concealed within the vehicles. He suggests that the mechanical construction of these vehicles may have resembled that of Guido da Vigevano's fighting-cars. Professor White also informs me that an illumination of a four-wheeled wagon, whose front wheels are larger than the rear—thus indicating a pivoted front axle—from the Trier *Apocalypse* (City Library MS. 31, fol. 58^r) illuminated in central Gaul c. 800, is to appear in his forthcoming volume on *Mediaeval Technology and Social Change*.

Personal Notes

AN APPRECIATION OF DAVID BERNARD STEINMAN (1886-1960)

SARA RUTH WATSON*

With the passing of David Bernard Steinman, not this Society alone but the whole world has lost a friend and co-worker. His extraordinary capacity for work and concentration, his creative genius, and his warm interest in his fellowman—these three qualities combined in him to make for greatness. Once, several years ago, he told me that nothing he had ever done had been wasted. Perhaps here is a key to the wholeness of this unusual personality.

David Steinman's career is an American "success" story, perhaps of a kind that is now impossible to achieve. In these days of the "organization engineer," of automation and standardization, the development of an unorthodox personality, of the "individual engineer," is an anachronism.

David was born in Brooklyn, of Lithuanian parents; his father supported half a dozen children in a three-room, cold-water apartment on the ten dollars a week he earned as a factory worker. David passed his childhood in the shadows of Brooklyn Bridge, which served as his inspiration and created the desire in him to become a civil engineer. At ten he taught himself algebra; at fourteen he was attending evening high school and spending his days scrambling around the steelwork of the Williamsburg Bridge, then under construction. He also attended Cooper Union. From City College of New York Steinman received a B. S. in 1906. He was graduated *summa cum laude* and Phi Beta Kappa, receiving many other honors and three scholarships which enabled him to continue his studies at Columbia. There he received the C. E. degree in 1909; the A. M. in 1909; and the Ph. D. in 1911. His thesis for the Civil Engineering degree was the "Design of the Henry Hudson Bridge as a Steel Arch"—a design Steinman actually built in 1935-37. This is but one of the examples of the continuity of his life, of the fact that no idea or deed was ever abortive. Also, his doctoral

* Dr. Watson is the author of *Famous Engineers* and of *Bridges in History and Legend* (with Wilbur Watson). She was co-author, with Dr. Steinman, of *Bridges and their Builders*.

dissertation, "Suspension Bridges and Cantilevers: Their Economic Proportions and Limiting Spans," was published and two editions sold out. As a result of his own experience in acquiring an education and working his way up, Steinman and his family, in 1955, established the Steinman Foundation for the purpose of making contributions and grants to educational institutions and other worthy causes. The principal objective is to make gifts to engineering schools for establishing scholarships, awards, and loans to aid deserving students to complete their engineering studies or to pursue full-time graduate work in engineering.

With his strong sense of service to man, Steinman had planned, all along, to teach; and so he became Professor of Civil Engineering at the University of Idaho from 1910 to 1914, and Professor of Civil and Mechanical Engineering at City College from 1917 to 1920. In the meantime he found time to marry a schoolteacher, Irene Hoffman, who was his lifelong companion and inspiration. She bore him three children: John Francis, Alberta, and David. At this time Steinman was special assistant to Gustav Lindenthal on the design and construction of Hell Gate Arch Bridge and other notable bridges.

In 1920 Steinman secured an appointment with the New York Central Railroad for designing, strengthening, and reconstructing bridges. Then, in the following year came a depression, and Steinman, laid off, walked the streets for three months searching for work. An older engineer suggested that Steinman go into private practice, and offered him desk room for ten dollars a month. His first fee was five dollars; the second month he made two hundred dollars. This was the beginning of Steinman's practice.

The firm of Robinson and Steinman was formed in 1924. Holton D. Robinson, an eminent bridge designer who had been the builder of the Williamsburg and Manhattan Bridges, called upon Steinman to collaborate in the design of the Florianapolis Bridge in Brazil. Their design won in an International Competition, and the engineers were awarded the contract. The building of this bridge marked a turning point in the science of suspension bridge technology. Its new form of stiffening truss makes the structure four times more rigid than is the conventional parallel-chord design and utilizes only two-thirds as much steel. The result was a substantial saving in cost of construction and a material increase in strength and safety. The partnership of Robinson and Steinman endured until the death of Robinson in 1945. Then Steinman carried the firm on, alone, until last year. Now the firm's name is Steinman, Boynton, Gronquist and London.

The firm has built over four hundred bridges, nine of which have received artistic bridge awards. These awards meant much to Steinman, for he waged a campaign for beauty in bridges. In his travels, lectures, and writings he stressed not only beauty of form and proportion

through fitness of design to function; he also pioneered in the use of color and artistic illumination. Notable structures of his design include the Mount Hope Bridge, Rhode Island; the Waldo-Hancock Bridge, Maine; the Charter Oak Bridge, Connecticut; the Henry Hudson Bridge, New York; the Raritan River Bridge, New Jersey; Thousand Islands International Bridge, New York; The St. John's Bridge, Oregon; the Carquinez Strait Bridge, California; the Mackinac Straits Bridge, Michigan.

The importance of Dr. Steinman's contribution to the science of bridge-building is inestimable. A recognized authority on long-span bridges, on the design of suspension bridges, on aerodynamic instability, he made many notable improvements and inventions. He simplified methods of analysis for bridge design and for indeterminate structures; he invented a new system of design loading for railroad bridges and new short-cut methods for solving higher-degree equations. Author of twelve books and 580 technical papers and articles, many of which have been translated into foreign languages, he received during his lifetime over 350 awards and citations—67 of which are from foreign countries, including the French Legion of Honor. He held 26 academic degrees, including four earned and 22 honorary ones. Twice he was awarded the Norman Medal of the American Society of Civil Engineers, the second time for his outstanding paper on the problem of bridge aerodynamics. The late Dr. Boris A. Bakhmeteff of Columbia University hailed this work as "the crowning accomplishment of a lifetime of endeavor."

Late in life, David Steinman began to write poetry. It is significant that he first made a thorough study of English prosody and sought the criticism of authorities. Many of his poems have been published; some have been set to music; and two collected editions have appeared. Steinman even composed music, at one time in his life. As a humanitarian, much of his work remains unheralded. Besides the establishment of the Steinman Foundation, David Steinman was active in Boy Scout work, in the National Bible Week Movement, in the Madison House Settlement. Because a fresh-air camp had meant so much to him in his boyhood, he was a generous contributor for over forty years to scores of these camps and to organizations for the aid of crippled children and of the blind. In addition, he constantly encouraged young engineers and devoted time and energy to societies for the advancement of the engineer's status. A fine sense of "noblesse oblige" drove him to help his fellowman in any way he could.

So he united and interwove all his capabilities, talents, and energies—to make the "complete man," a modern-day Renaissance man, in whom were integrated the scientist, artist, lecturer, educator, poet, and humanist. The feeling of oneness in the human experience was ever-present in David Steinman, and it is this idea which I think he was

expressing when he said that nothing he had ever done or thought had been lost. In his address " The Spiritual Challenge of the Atomic Age," he speaks of himself:

> St. Thomas Aquinas once said that there are only three really important endeavors in life; to have faith in the right things, to hope for the right things, to love the right things in life. Our faith, hope, and love for the good, the true, and the beautiful find their expression in science, religion, and art. These are the three main pillars of civilization. For man's highest fulfillment, we must revere all three. Religion, art, and science, representing the everlasting search for the good, the true, and the beautiful, constitute a trinity of human aspiration. All three are but different aspects of the same reality, of the same feeling for the sublime, rooted in the supreme mystery of being.
>
> It has been pointed out that there is a common and unifying element—what we identify instinctively as the divine spark—in a Raphael Madonna, a Beethoven symphony, a discovery by Copernicus, Newton, an Einstein. In each instance, inspiration was drawn from some common reservoir of spiritual vitality. . . . The experience of sudden inner illumination beyond mere intelligence, the inner light known to mystics, martyrs, and poets, is not unknown to creative scientists and inventors.

A Selected Bibliography of the Writings of David Bernard Steinman

(From a Bibliography by Rensselaer Polytechnic Institute, Troy, N. Y., 1955)

A. Books

Suspension Bridges and Cantilevers, their Economic Proportions and Limiting Spans. Van Nostrand: N. Y., 1911; 2nd ed. rev., 1913.

A Practical Treatise on Suspension Bridges; Their Design, Construction, and Erection. Wiley: N. Y., 1922; 2nd ed. rev., 1929.

Melan, Joseph. *Theory of Arches and Suspension Bridges*, tr. by D. B. Steinman. M. C. Clark Pub. Co.: Chicago, 1913.

The Wichert Truss. Van Nostrand: N. Y., 1932.

Bridges and Their Builders. Co-author, Sara Ruth Watson. G. P. Putnam's Sons: N. Y., 1941; 2nd ed. rev. Dover Publications: N. Y., 1950.

The Builders of the Bridge; The Story of John Roebling and His Son. Harcourt, Brace: N. Y., 1945; 2nd ed., 1950.

Miracle Bridge at Mackinac, in collaboration with John T. Nevill, W. B. Eerdmans Pub. Co.: Grand Rapids, Mich., 1957.

B. Articles

"Beauty in Bridges," *Hudson Engineering Journal* (Aug. 23, 1945).

"Beauty in Modern Bridge Structures," *Civil Engineering*, 7, 8 (July, 1938).

"World's Most Notable Bridges," *Engineering News-Record*, 141 (Dec. 9, 1948), pp. 92, 94.

"Bridges–Past, Present and Future," *Scientific American*, 191, 5 (Nov., 1954), pp. 61-71.

"The Fiftieth Anniversary of the Brooklyn Bridge," *American Engineer*, 3, 7 (July, 1933), pp. 16-17.

"Fifty Years of Progress in Bridge Engineering," *American Highways*, 10, 4 (Oct., 1931), pp. 7-11.

"How Bridges Have Increased Man's Mobility," *Scientific Monthly*, 74, 10 (Oct., 1952), pp. 207-214.

"Aerodynamic Theory of Bridge Oscillations," *American Society of Civil Engineers Proceedings*, 75, 8 (Oct. 1949), pp. 1147-1184 (Awarded the Norman medal in 1951).

"Bridges–A Comparative Study of Limiting Span, Maximum Span and Economic Span for Suspension Bridges and Cantilever Bridges," *Engineering and Contracting*, 39, 19 (May 7, 1913), pp. 518-523.

"The Place of the Engineer in Civilization"; A series of addresses delivered at N. C. State College, Raleigh. *State College Record*, 38, 11 (June, 1939), 51 pp.

Bibliographical Notes

A BIOGRAPHICAL BIBLIOGRAPHY OF ELECTRICAL ENGINEERS AND ELECTROPHYSICISTS (PART I)

THOMAS JAMES HIGGINS*

For over two decades the author has sought out papers, books, monographs, pamphlets, and other written sources dealing with the historical developments of electrical engineering and of electrophysics and with the lives and work of noted electrical engineers and electrophysicists. This search, confined to materials in English, has gradually broadened through the years, so that it now encompasses (1) complete files to date of the pertinent serial publications; (2) the stacks and card catalogs of most of the important university, public, and technical libraries in the East and Middle West; (3) the accumulated catalogs of the principal publishers of technical and scientific texts; (4) the lists of offerings, over the past twenty years, of the larger dealers in used and rare scientific and technical works; and (5) much relevant miscellaneous bibliographical material—book indexes, printed catalogs of libraries, surveys of special collections, and kindred aids.

A few years ago, in the belief that the greater part of of the most important material had been located and that the results of this search could be made available for the professional use of others, the author compiled the consequential items of a nonpersonal nature in a bibliography of some 1,200 titles ("A Classified Bibliography of Publications on the History and Development of Electrical Engineering and Electrophysics," *The Bulletin of Bibliography*, XX, Nos. 3-7 [1950-1952]). That bibliography deals only with the development of the subject matter itself; it is not concerned with the individuals who have advanced either the theory or the application of electricity.

However, a bibliography concerned only with the subject matter of electrical engineering and electrophysics does not afford the whole story. Engineering knowledge does not grow of itself; behind each

* A Professor of Electrical Engineering at the University of Wisconsin, Thomas J. Higgins has been active in many aspects of engineering education, including the publication of over 135 papers in scientific and technical journals. In 1954 he was awarded the George Westinghouse Award of the American Society for Engineering Education for his contributions to teaching and scholarship.

accomplishment there is a man or men—individuals whose personalities and circumstances have affected their work. In such fact, biographical studies are necessary to round out an account of scientific and engineering advance.*

The chief significance of biographical study lies in its aid to understanding the development of engineering and the relations of technological developments to scientific and cultural activity. To familiarize oneself with the lives, the work, and the accomplishments of the leading electrical engineers and electrophysicists is simultaneously to acquaint oneself with the method and thought of genius, as well as with the philosophical and cultural activities and the economic, political, and social problems of their times. By reading about the personal lives of engineers and scientists, the student witnesses the conception of idea, the birth of actuality, the growth of application. He learns that science and technology is a constantly developing organism of formidable pedigree and notable ancestry; he appreciates the coordinated effort necessary for the successful formulation of engineering theory and perceives its rational development; he gauges the relative importance of individual contributions, understands how these have been integrated into a orderly whole; and, above all, he learns to prize the resultant structure of science and technology and to be open to new ideas and changes in his own theory and practice.

With this awareness of the importance of the biographical element in understanding and appreciating the development of engineering, the author has moved to extend his previously published bibliography by this complementary list of some 1,200 titles embracing the accounts—autobiographical, biographical, and reminiscences of others—of men who substantially advanced either the theory or the application of electricity. Taken together, these two bibliographies provide an outline of—or better yet, an index to—the history of the development of electrical engineering and electrophysics. They are comprehensive—practically every phase of electrophysics and electrical engineering is treated; exhaustive—they give much detail on any given phase of development, which is beyond the scope of any ordinary volume; and authoritative—they were largely written either by the men themselves or by men who were coeval with or instrumental in the development of the topic discussed. These bibliographies, therefore, provide us with sources and raw material for further investigation of the men and their contributions. They can help enrich our knowledge, and, hopefully, inspire students of the future to emulate the great men of the past, following Emerson's dictum: "I cannot even hear of personal vigor of any kind, great power of performance, without fresh resolution."

* An especially interesting substantiation of this point is enfolded in the recent critical study by G. Holton, "On the Origins of the Special Theory of Relativity," *American Journal of Physics*, XXVIII [1960], pp. 627-636.

The biographical bibliography below is divided into two parts: the first comprises books, the second comprises items published in periodicals. In each part individual items are listed alphabetically by the surname of the person concerned, multiple items concerning an individual being listed chronologically. To avoid excessive duplication, listing of books comprises items not already entered in the author's earlier papers: T. J. Higgins, "Book-length Biographies of Physicists and Astronomers," American Journal of Physics, XII (1944), pp. 31-39, 234-236; XVI (1948), pp. 180-182; T. J. Higgins, "Book-length Biographies of Engineers, Metallurgists and Industrialists," The Bulletin of Bibliography, XVIII (1946), pp. 206-210, 235-239; XIX (1947), pp. 10-12.

Part I: Books

Man of High Fidelity, Edwin Howard Armstrong, L. Lessing (Lippincott, Phila., 1956) 320 pp.

Alexander Dallas Bache, Scientist [Geomagnetism] and Educator, 1806-1867, M. M. Odgers. (Univ. of Pennsylvania, Phila., 1947) 233 pp.

John Baird, The Romance and Tragedy of the Pioneer of Television, S. Moseley. (Odhams Press, London, 1952) 256 pp.

The Talking Wire: The Story of Alexander Graham Bell, O. J. Stevenson. (Bodley Head, London, 1954) 158 pp.

Billings and Water Power in Brazil: A Short Biography of Asa White Kenney Billings, Hydroelectric Engineer, A. J. Ackerman. (Amer. Soc. of Civil Engineers, New York, 1953) 128 pp.

A Romance in Research: The Life of Charles F. Burgess – Student – Teacher – Researcher –Industrialist, Alexander McQueen. (Instruments Publishing Company, Pittsburgh, 1951) 429 pp.

What Burlingame Did; A True Story of a Young Electrician, R. Cleveland. (San Francisco, 1908) 90 pp.

John J. Carty, An Appreciation, F. L. Rhodes. N. Y., 1932) 280 pp.

Henry Cavendish: His Life and Scientific Work, A. J. Berry. (Hutchinson, London, 1960) 208 pp.

From the Life of a Researcher [William Weber Coblentz], W. W. Coblentz. (Philosophical Library, N. Y., 1951) 238 pp.

Cottrell: Samaritan of Science, F. Cameron. (Doubleday, N. Y., 1952) 414 pp.

Colonel R. E. B. Crompton and the Evolution of the Electrical Industry, J. H. Johnson and W. L. Randell. (Longmans, London, 1945, revised 1946) 27 pp.

Memorials, Scientific and Literary, of Andrew Crosse, the Electrician, C. Crosse. (Longmans, . . . , Roberts, London, 1857) 360 pp.

Biography of Thomas Davenport, The "Brandon Blacksmith," Inventor of the Electric Motor, W. R. Davenport. (Vermont Historical Society, Montpelier, 1929), 165 pp.

Father of Radio, The Autobiography of Lee De Forest, Lee de Forest. (Wilcox and Follett, Chicago, 1950) 502 pp.

Tom Edison. Boy Inventor, S. J. Guthridge. (Bobbs-Merrill, Indianapolis, 1947) 200 pp.

The Diary and Sundry Observations of Thomas Alva Edison, edited by D. D. Runes. (Philosophical Library, N. Y., 1948) 277 pp.

Thomas Alva Edison, Inventor, R. C. Weir. (Abingdon-Cokesbury, N. Y., 1953) 128 pp.

Edison, M. Josephson. (McGraw-Hill, N. Y., 1959) 513 pp.

An Engineer's Outlook, J. A. Ewing. (Methuen, London, 1933) 333 pp.

Sir Alfred Ewing. A Pioneer in Physics and Engineering, L. F. Bates. (Longmans, London, 1946) 38 pp.

The Letters of Faraday and Schoenbein, 1836-1862; edited by G. W. A. Kohlbaum, F. V. Darbishire. (Williams and Norgate, London, 1899) 376 pp.

Faraday Centenary Exhibition, 23 Sept. to 3 Oct., 1931, Souvenir Catalog and Guide. (London, 1931) 248 pp.

Faraday Discloses Electromagnetic Induction, B. Dibner. (Burndy Library, N. Y., 1949) 23 pp.

Faraday's Discovery of Electro-Magnetic Induction, T. Martin. (Edward Arnold, London, 1949) 160 pp.

Michael Faraday: from Errand Boy to Master Physicist, Harry Sootin. (Messner, N. Y., 1954) 180 pp. A fictional biography.

Michael Faraday: Man of Simplicity, J. Kendall. (Faber and Faber, London, 1955) 196 pp.

Story of Television: The Life of Philo T. Farnsworth, G. Everson. (Norton, N. Y., 1949) 266 pp.

Life and Letters of Sebastian Ziani De Ferranti, G. Z. De Ferranti and R. B. Ince. (Williams and Norgate, London, 1934) 240 pp.

S. Z. De Ferranti, W. L. Randell. (British Council, Longmans, London and N. Y., 1943) 29 pp.

The Inventor of the Valve: A Biography of Sir Ambrose Fleming, J. T. McGregor-Morris. (The Television Society, London, 1954) 141 pp.

Forbes: Telephone Pioneer, A. S. Pier. (Dodd, Mead, N. Y., 1953) 232 pp.

Memoirs of the Life and Writings of Benjamin Franklin . . . , edited by W. T. Franklin. (H. Colburn, London, 1817-18, 3 volumes; new extended edition, 1833, 6 volumes of the second 1818-19 edition.)

The Life of Benjamin Franklin Containing the Autobiography, with Notes and a Continuation, J. Sparks. (Tappan and Dennet, Boston, 1844) 612 pp.

From Printing Office to the Court of St. James: The Boyhood and Manhood of Benjamin Franklin, W. M. Thayer. (Hodder and Stoughton, London, 2nd edn., 1895) 380 pp.

Benjamin Franklin, The First Civilized American, P. Russell. (Brentano, N. Y., eighth printing 1927) 352 pp.

General Benjamin Franklin: The Military Career of a Philosopher, J. B. Nolan. (Oxford, London; Univ. of Pennsylvania, Phila., 1936) 101 pp.

Benjamin Franklin in Scotland and Ireland, 1759 and 1771, J. B. Nolan. (Univ. of Pennsylvania, Phila., Oxford, London, 1938) 229 pp.

Benjamin Franklin, A Biography, E. S. Scudder. (Collins, London, 1939) 428 pp.

Benjamin Frankin's Autobiographical Writings, C. Van Doren. (Viking, N. Y., 1945) 810 pp.

Autobiography, B. Franklin. (A restoration of a "fair copy" by Max Farrand.) Univ. of California, Berkeley, 1949) 210 pp.

Benjamin Franklin and Catherine Ray Greene, Their Correspondence 1755-1790, W. G. Roelker (editor). (American Philosophical Society, Phila., 1949) 147 pp.

The Letters of Benjamin Franklin and Jane Mecom, C. Van Doren (editor). (Princeton Univ. [for the American Philosophical Society], Princeton, 1950) 380 pp.

Jane Mecom. The Favorite Sister of Benjamin Franklin, C. Van Doren. (Viking, N. Y., 1950) 225 pp.

Benjamin Franklin: His Contribution to the American Tradition, I. B. Cohen. (Bobbs-Merrill, Indianapolis, 1953) 320 pp.

Benjamin Franklin and a Rising People, V. W. Crane. (Little, Brown, Boston, 1954) 219 pp.

Franklin and Newton: [An Inquiry into Speculative Newtonian Experimental Science and Franklin's Work in Electricity as an Example Thereof], I. B. Cohen. (American Philosophical Society, Phila., 1956) 657 pp.

Mr. Franklin. A Selection from His Personal Letters, L. Labaree and W. J. Bell., Jr. (editors). (Yale, New Haven, 1956) 61 pp.

Franklin and His Contemporaries, A. O. Aldridge. (New York Univ., N. Y., 1957) 260 pp.

Benjamin Franklin's Unfinished Business. Story of the International Celebration of the 200th Anniversary of the Birth of Benjamin Franklin—1706-1956, H. Jordan and C. Jordan (editors). (Franklin Institute, Phila., 1957) 315 pp. (contains 79 pages of illustrations).

Carl Friedrich Gauss: Titan of Science: A Study of His Life and Work, G. W. Dunnington. (Exposition, N. Y., 1955) 479 pp.

Josiah Willard Gibbs: The History of a Great Mind, L. P. Wheeler. (Yale, New Haven, 1951) 264 pp.

Notes on the De Magnete of Dr. William Gilbert, [To Accompany the Gilbert Club Translation], S. P. Thompson. (Charles Whittingham, London, 1900) 67 pp.

The Family and Arms of Gilbert of Colchester, S. P. Thompson. (Chiswick, London, 1903.)

Gilbert of Colchester, Father of Electrical Science, S. P. Thompson. (Chiswick, London, 1903.)

The De Magnete of William Gilbert [and his Life], D. H. D. Roller. (Menno Hertzberger, Amsterdam, 1959) 196 pp.

Oliver Heaviside and the Mathematical Theory of Electrical Communication, G. Lee. (Longmans, London, 1947) 32 pp.

Herman Ludwig Ferdinand von Helmholtz, J. G. McKendrick. (Unwin, London, 1909) 299 pp.

Life and Work of Joseph Henry, F. L. Pope. (American Electrical Society, N. Y., 1879).

Joseph Henry: His Life and Work, Thomas Coulson. (Princeton University Press, 1949) 280 pp.

Professional Amateur, The Biography of Charles Franklin Kettering, T. A. Boyd. (Dutton, N. Y., 1957) 242 pp.

Morse's Patent. Full Exposure of Dr. Charles T. Jackson's Pretentions to the Invention of the American Electro-Magnetic Telegraph, A. Kendall. (J. T. Towers, Washington, D. C., 1852) 64 pp.

Sir James Jeans, E. A. Milne. (Cambridge University Press, 1952) 176 pp.

Benjamin Garver Lamme, Electrical Engineer: An Autobiography, B. G. Lamme. Putnam's, London and N. Y., 1926) 271 pp.

My Philosophy, Representing My Views on the Many Functions of the Ether of Space, Sir Oliver Lodge. (Ernest Benn, London, 1933) 318 pp.

H. A. Lorentz: Impressions of His Life and Work, G. L. D. De Haas-Lorentz (editor). (North-Holland Publishing Co., Amsterdam, 1957) 172 pp.

He Lit the Lamp. A Biography of Professor A. M. Low, V. Bloom. (Burke, London, 1958) 214 pp.

Marconi, The Man and His Wireless, O. E. Dunlap, Jr. (MacMillan, N. Y., 1937) 357 pp.; revised edition, 1938, 362 pp.

Origins of Clerk Maxwell's Electrical Ideas, edited by J. Larmor. (Cambridge University Press, 1937) 56 pp.

James Clerk Maxwell, F. R. S., 1831-1879, R. L. Smith-Rose (Longmans, London, 1948) 34 pp.

Antonio Meucci, Inventor of the Telephone, G. E. Schiaro. (Vigo, New York, 1959.)

The Autobiography of Robert A. Millikan, R. A. Millikan. (Prentice-Hall, N. Y., 1950) 311 pp.

A Memorial of Samuel F. B. Morse, From the City of Boston. (Boston, 1872) 103 pp.

The Telegraph in America and Morse Memorial, J. D. Reid. (J. Polhemus, N. Y., 1886) 894 pp.

Samuel F. B. Morse and American Democratic Art, O. W. Lincoln. (Little, Brown, Boston, 1954) 215 pp.

Menlo Park Reminiscences, F. Jehl. (Edison Institute, Dearborn, Mich., 1936) 430 pp.

The Hon. Sir Charles A. Parsons, Born One Hundred Years Ago on 13th June, 1854. (C. A. Carsons, Newcastle-upon-Tyne, 1954) 39 pp.

Anton Philips of Eindhoven, P. J. Bouman, translation by F. G. Renier and A. Cliff. (Weidenfeld and Nicolson, London, 1958) 25 pp.

The Crucible. The Story of Joseph Priestley, L. L. D., F. R. S., J. G. Gillam. (Robert Hale, London, 1954) 243 pp.

Elias E. Ries, Inventor, E. H. Ries. (Philosophical Library, N. Y., 1951) 369 pp.

Roemer and the First Determination of the Velocity of Light, I. B. Cohen. (Burndy Library, New York, 2nd edn., 1944) 63 pp.

Dr. W. C. Rontgen, O. Glasser. (Charles C. Thomas, Sprinffield, Ill., 2nd edn., 1958) 169 pp.

Lord Rutherford, By Those Who Knew Him: Being the Collection of the First Five Rutherford Lectures of the Physical Society, edited by F. A. B. Ward. (The Physical Society, London, 1954) 69 pp.

Ernest Rutherford, Atom Pioneer, John Rowland. (Philosophical Library, N. Y., 1957) 160 pp.

Pioneer Research on the Atom; Rutherford and Soddy in a Glorious Chapter of Science. The Life Story of Frederick Soddy, M. A., L. L. D., F. R. S., Nobel Laureate, M. Howorth. (New World Publications, London, n. d.)

The Life of Sir Wm. Siemens, W. Pole. (J. Murray, London, 1888) 412 pp.

Frank J. Sprague Anniversary Committee. A Meeting of Appreciation and Tribute to Frank J. Sprague on the Occasion of His Seventy-Fifth Birthday, July 25, 1932. (N. Y., 1932) 53 pp.

Frank Julian Sprague, Father of Electric Traction. 1857-1934. H. C. Passer. (Harvard, Cambridge, Mass., 1952) 26 pp.

Steinmetz and His Discoverer, J. T. Broderick. (Robson and Adee, Schenectady, N. Y., 1924) 23 pp.

A Magician of Science, The Boy's Life of Steinmetz, J. W. Hammond. (Century, London and N. Y., 1926, 1943) 210 pp.

The Inventions, Researches, and Writings of Nikola Tesla, with Special Reference to His Work in Polyphase Currents and High Potential Lighting, T. C. Martin. (The Electrical Engineer, N. Y., 1894) 469 pp.

Prodigal Genius, The Life of Nikola Tesla, J. J. O'Neill. (Ives Washburn, N. Y., 1944) 326 pp.

Nikola Tesla Lectures, Patents, Articles. (Nikola Tesla Museum, Belgrade, 1956) 802 pp.

Three Steps to Victory: A Personal Account of Radar's Greatest Pioneer, Sir R. Watson-Watt. (Odhams, London, 1957) 480 pp. Published in the United States as The Pulse of Radar, The Autobiography of Sir Watson-Watt (Dial, N. Y., 1959) 438 pp.

George Westinghouse, 1846-1914; A Tribute, A. Warren. (Distributed by the Westinghouse Electric Company, 1914) 32 pp.

A Life of George Westinghouse . . . [1846-1914] H. G. Prout. (Scribner's, N. Y., 1922) 375 pp.

George Westinghouse, His Life and Achivements, F. Crane. (W. H. Wise, N. Y., 1925) 34 pp.

A Measure for Greatness; A Short Biography of Edward Weston, D. O. Woodbury. (McGraw-Hill, N. Y., 1949), 230 pp.

Invention of the Electric Telegraph: The Charge Against Sir Charles Wheatstone, of Tampering with the Press [as evidenced by a letter to the Editor of the Quarterly Review in 1855], Rev. T. F. Cooke. (R. E. Peach, Bath; Simpkin, Marshall, London, 1869.)

Willis Rodney Whitney, Pioneer of Industrial Research, J. T. Broderick. (Fort Orange Press, Albany, New York, 1945) 324 pp.

The Telegraph in America. Its Founders, Promoters, and Noted Men, J. D. Reid. (Derby Brothers, N. Y., 1879) 846 pp.

Telegraphers of Today; Description, Historical, Biographical, compiled by J. B. Taltavall. (John B. Taltavall, N. Y., 1894) 354 pp.

Inventors, P. G. Hubert, Jr. (Scribner's, N. Y., 1896) 299 pp.

Invention and Discovery, (No author listed in Library of Congress cards). (Doubleday, Page, N. Y., 1902) 183 pp. Franklin, Faraday, Henry, Illes, Bell.

Forty Years with General Electric [and its Men], J. T. Broderick. (Fort Orange Press, Albany, N. Y., 1929) 218 pp.

American Inventors, C. J. Hylander. (MacMillan, N. Y., 1934) 216 pp.

British Scientists, Sir R. Gregory. (William Collins, London, 1941) 48 pp. Faraday, Priestley, Maxwell, Thomson, Rutherford, Bragg, Rayleigh, and others.

Men and Volts: The Story of General Electric [and its Scientists], J. W. Hammond. (Lippincott, London and N. Y., 1941) 436 pp.

Living Biographies of Great Scientists, H. T. Schnittkind, D. L. Thomas. (Garden City, N. Y., 1941) 314 pp.

Radio's 100 Men of Science; Biographical Narratives of Pathfinders in Radio, Electronics and Television, O. E. Dunlap. (Harper, London and N. Y., 1944) 294 pp.

Men of Science in America: The Role of Science in the Growth of Our Country, B. Jaffe. (Simon and Schuster, N. Y., 1944) 600 pp.

The Royal Institution [and its Professors], T. Martin. (Longmans, Rev. edn., 1948) 52 pp. Davy, Young, Faraday, Tyndall, Dewar, Bragg.

Sons of Science. The Story of the Smithsonian Institution and of its Leaders, P. H. Oehser. (Henry Schuman, N. Y., 1949) 220 pp. Henry and others.

British Scientists, E. J. Holmyard. (J. M. Dent, London; Philosophical Library, N. Y., 1951) 88 pp. Priestley, Faraday, Kelvin, Rutherford, and others.

The Bright Design. Electrical Energy and the Men Who Have Traced its Patterns, K. B. Shippen. (Viking, N. Y., 1951) 207 pp.

British Scientists of the 20th Century, J. G. Crowther. (Routledge and Kegan Paul, London, 1952) 320 pp. Thomson, Rutherford, Jeans, and others.

Six Great Inventors: Watt; Stephenson; Edison; Marconi; Wright Brothers; Whittle, J. G. Crowther. (Hamish Hamilton, London, 1954) 255 pp.

Ten Founding Fathers of the Electrical Science, B. Dibner. (Burndy Library, Norwalk, Conn., 1954) 46 pp. Gilbert, von Guericke, Franklin, Volta, Ampere, Ohm, Gauss, Faraday, Henry, Maxwell.

Makers of Modern Science, (Times Publishing, London, 1956) 44 pp. Faraday, Thomson, Rutherford, and others.

Lives in Science [A Reprint of Biographies Published in the Scientific American], (Simon and Schuster, N. Y.) 214 pp. Fitzgerald, Priestley, Franklin, Maxwell, Faraday, Henry, and others.

Six Great Engineers: Delesseps, Brunel, Westinghouse, Parsons, Diesel, and Hinton, J. G. Crowther. (Hamish Hamilton, London, 1959) 176 pp.

("Part II: Periodical Items" of this Bibliography will be published in the next issue of *Technology and Culture*.)

Book Reviews

The Story of Engineering. By James Kip Finch. Garden City, New York: Anchor Books, Doubleday & Co., 1960. Pp. xxvii, 528. 118 illustrations. $1.45.

The Dean Emeritus of the School of Engineering of Columbia University, author of an earlier *Engineering and Western Civilization*, has presented us with a new history of engineering. This history is mainly concerned with bridges and roads, dams and canals, mines and machines, but the later chapters also discuss the most important inventions in the field of chemical and electrical engineering, which are important to the architect and civil engineer. Issuing from the pen of a man so widely known in engineering education and so close to practical engineering, such a book will naturally draw our attention, and it fully deserves it.

Dean Finch has set out to tell the story of the evolution of the various engineering crafts from the ancient "master builder" who became an "architect-engineer" in classical times, then an "artist-architect-engineer" during the Renaissance, until eventually these "higher craftsmen" specialized and used the results of the new science to transmute their craft into a "developed science and a developed practical art." He also set out to show the "impact of engineering advances on the life of their day," which prove unreservedly that engineers are makers of history. Throughout his story he uses the personalities who made major contributions to these advances as the theme and he gives us the pertinent facts of their lives and their achievements.

His chapters on the engineers of the Renaissance and the Age of Books (the majority of which were indeed engineering handbooks summarizing the experience of generations of skilled craftsmen) lead him to a discussion of the rebirth of engineering in seventeenth-century France and the great French engineers and engineering schools of the following century, the achievements of the pioneer British engineers of the same eighteenth century, and the great European engineers of the Victorian Age. His chapters on American civil engineering and the American mining engineer in the nineteenth century are particularly readable. They are followed by chapters on mechanical and electrical engineering during the same century. Six more chapters are devoted to engineering in the twentieth century, and here special attention is given to the new materials (steel, aluminum, concrete, and reinforced concrete), chemical engineering, power and machines, electrical service

and communication, and the great canals, highways, and bridges of our age.

These 400 pages are by far the best of this book. Like so many of us, Dean Finch has tried to cover the entire history of engineering and, like the rest of us, he must have found so huge a canvas beyond one single individual. In order to write a completely satisfactory history of engineering of any period one must be both a good engineer and a good historian with a sound knowledge of the pertinent literature. I am afraid that we all fail in regard to this stringent demand. Hence the master strokes with which Dean Finch illustrates the last five centuries of engineering fail him in the earlier hundred pages designed to cover the pre-classical, classical, and medieval periods, roughly forty-five centuries. I am afraid that the lack of personal acquaintance with the written sources (alas, often in ancient languages only half understood by the philologist, who is *not* an engineer and who seldom has any understanding of such crafts as are mentioned in his texts) has made this part rather anecdotal. The few references he gives would seem to point out that he is not quite aware of certain recent publications in this field, though his discussion of such engineering feats as the Jerwan aqueduct, Roman bridges and hydraulic engineering works, and certain monuments of medieval engineering are always interesting and food for further thought. Here the picture is not fully worked out, and a few strokes of a master brush indicate the pattern only. Still, this is a book which will certainly awaken interest in the history of engineering in the younger generation.

I regret that the author has not given us a more extensive bibliography than the incidental references in a few footnotes dispersed through the book. The publishers are no doubt to blame for the lack of a proper index, without which no book, not even a paper-back, should be printed. The data and discussions in this book are too valuable to be lost because of the lack of such an index!

R. J. Forbes *

A History of Mechanical Inventions. By Abbott Payson Usher. Boston: Beacon Press, 1959. Pp. xiv, 450. Paperbound. $2.25.

Although this book is an established classic, it has not been widely recognized as a guide and aid to the conduct of research in the history of technology. Indeed, in its role as a methodological aid it has been a "sleeper." Consequently, its recent appearance in a less expensive

* One of the world's outstanding authorities on the history of technology, Dr. Forbes, of Amsterdam, was elected to Corresponding Membership in the Society for the History of Technology in 1959.

paperback edition is doubly welcome. Its wider dissemination may assist more investigators to deal more meaningfully with the massive array of technical mechanical and scientific details that await them in their own particular bailiwicks of historical research. Further, it may assist them in establishing the relevance of their separate "pedantic chases after the insignificant" (as Powicke put it) to those larger movements of history, the contemplation of which is too often studiously avoided by contemporary scholarship.

Only a new preface distinguishes the new paperback from the hardback version of the revised edition of 1954. The last four-fifths of the book comprise a vertical—and at first glance arbitrary—slice, through time, of the vast history of mechanical invention from antiquity to the twentieth century. This slice from the history of European technology shows, with impressive success, the rise of the use of power machinery to substitute for human and animal muscles and the evolution of precision machinery to tell time and to substitute for human dexterity. But to understand why the author also included chapters on "The Early History of the Pure and Applied Mechanical Sciences" (mislabeled in the table of contents), on "The Mechanical Equipment of Pre-Christian Antiquity," and on "The Invention of Printing," the reader must immerse himself in the prefaces and the first four chapters.

Such immersion is also desirable because Professor Usher has been more successful than most in adapting his method of conducting specialized historical research to his subject-matter. Neither a journalist's assortment of events nor a transcendentalist's recitation of heroic creative acts by inexplicable genius, his subject-matter is a genetic historical process—in this instance the history of mechanical inventions. The key to Professor Usher's brilliant success in explaining how new things have occurred is his understanding of the manner in which new ideas, new inventions, rest upon and rise out of the old. It is this understanding of a developing process that he spreads out in conscientious detail in his first four chapters.

The essence of his research approach he once set forth at the urging of a seminar (of which this reviewer was a member) at the University of Wisconsin. His remarks are worth repeating, for they set the theme of his introductory chapters, they account for the organization and content of his *History of Mechanical Inventions*, and they explain both his theory of invention and his method of investigating how new things occur. To quote him:

> Our cultural achievements are the work of successive generations of superior personalities. Our cultures consist of knowledge that accumulates progressively by the absorption of small, individual items of novelty into a body of organized knowledge. Change is not an infrequent phenomenon centered around a small number of achievements of great magnitude. It is a persistent

> phenomenon involving many items and many personalities. The concepts of heroes and of men of genius are literary and cult devices that simplify the historical record. Therefore, it is important to recognize that such accounts of historical events do not adequately represent the actual processes by which we master our techniques and administer our affairs.

Any researcher who has sought in vain for helpful historical insights in the writings of students, scholars, or administrators preoccupied with the problem of who was *really* first, say, to comprehend the so-called Pythagorean theorem or to discover the composition of water or to devise the lathe or to invent the airplane or to make the first steamboat that "really" worked—any researcher who has struggled with such well-meant but limiting questions will welcome the careful theory of invention that has become also, under Professor Usher's hands, a theory of inquiry and a guide to the conduct of historical research.

At the core of his theory are the postulates that the human processes effecting change and innovation are virtually the same today as in the past, and that any specific event emerges from a specific genetic sequence of prior events which it is the historian's task to identify. In his concern with the human creative processes "by which we master our techniques and administer our affairs," Professor Usher regards mechanical invention as a typical example of the emergence of novelty in human thought and action, and he holds that the emergence of novelty results from processes of thought and action that are common to all men and all levels of mental activity. The human creative processes are not to be explained simply in mechanistic terms nor are they to be considered as mystically transcending all explanation. They involve inventive, creative acts by individuals, and these acts are not rare, unusual, inexplicable phenomena that defy analysis by the historian. Instead, they are a continuous feature of human behavior. They are to be found throughout the entire spectrum of human activity. They constitute a social process involving many individuals, a process to which no single individual is indispensable. In consequence, they are to be examined by the historian as individual acts socially conditioned, and when they are so examined, then the contingency and the circumstances provoking their appearance become the focus of the historian's attention, in order that he may uncover "the features of the processes by which man makes himself." (The reader interested in pursuing these ideas further is referred to A. P. Usher, "The Significance of Modern Empiricism . . . ," *The Journal of Economic History*, Vol. IX [1949], pp. 137-155.)

In presenting his theory of invention, Professor Usher makes no brief for its immaculate finality but urges instead that historians test

and develop it in the using. At the present juncture, its careful use offers hope that new sense will be made of technological history, the kind of sense that will represent an orderly clearing out of the Augean stable of esoteric, mountainously dull technological and engineering details that most historians hitherto have ignored, and the kind of sense that will enable technological history to receive the intelligent attention it deserves but has not yet received in the general textbooks.

THOMAS M. SMITH *

Rings Around the World: Man's Progress from Steam Engine to Satellite. By Heinz Gartmann. New York: William Morrow & Company, 1959. Pp. xv, 359. Index. Bibliography. Illustrations: 74 line drawings, 58 half-tones. $5.95.

The wide interest in the amazing, vital development of transportation and communication in our modern world is shown by the rapidity with which the original German edition of this fascinating volume has been translated and published in a number of languages in various European countries, as well as in the United States. The striking German title, *Sonst Stünde die Welt still: Das grosse Ringen um das Neue* (Econ Verlag GMBH, Düsseldorf, Pressehaus), became in the edition published by Hodder & Stoughton Ltd., in England, *Science as History: The Story of Man's Technological Progress from Steam to Satellite.* The able translator for the American edition is Alan G. Readett.

The author himself, Heinz Gartmann, is a German engineer, a graduate of the Institute of Technology in Berlin, and a fellow of various interplanetary societies, who has written some books for the general public and many articles for technical and popular journals in Europe. In 1950, he founded a scientific magazine for the advancement of rocket technology. In this present volume he continues in the field of his previous books, *Man Unlimited* and *Wings for our Century*.

In eight rather long and comprehensive chapters the author uses with skill the biographical method, citing largely European and in particular German sources, and describing the work of foreign scientists who, rather than Americans, were the original innovators. He gives a highly interesting survey of the evolution of new machines in transportation and communication, and the unceasing battles of each

* Dr. Smith, Assistant Professor of the History of Science at the University of Oklahoma, is a member of the Advisory Council of the Society for the History of Technology.

inventor against prejudice, and men's inherent resistance to change. Gartmann does this with a great array of anecdotes and illustrations, some of them from his own memories of associations with those on the firing line among scientific and engineering pioneers.

His first two chapters deal with the revolution in prime movers, viz., the invention of the steam engine, and the revolution on wheels through the locomotive and the automobile. In treating these topics Gartmann is not only factual but interpretive. He gives some enlightening details of the predecessors of James Watt, e. g., Denis Papin, an early inventor of the steam engine at the turn of the seventeenth into the eighteenth century, a time which was ripe for the new machine, but for which the men were not ready. Again, in order to indicate what specifically Watt really did accomplish, the author gives the full text of Watt's patent issued in 1769, one of the most important in history. Despite the remarkable way in which Watt had multiplied the power of men, Gartmann describes, with relevant detail, the slow spread of the new machine and the obstacles it had to overcome on the continent of Europe. Although Watt himself was aware that the steam engine was not merely a stationary machine, but could be used to drive carriages, it was only in 1813 that the first true locomotive, with smooth wheels on a smooth track, was built by Hedley, the "Puffing Billy." The railroad triumphed for economic reasons in Europe, viz., the "old system of conveying goods by river and canal was unable to keep pace with increasing production of goods" to be transported. Gartmann points out that in America the railway fulfilled a different purpose, viz., to transform an enormous, empty continent into a huge agricultural and industrial country. But while remarkable thus far in its results, machine power had to be much more highly concentrated before man could undertake mechanical locomotion on roads or in the air.

It was nearly half a century after the first locomotive ran that, in 1860, was heard the first of the four great names in the history of the internal combustion engine, Lenoir; the other three being Otto, Daimler, and Diesel. Indeed, it was only after Daimler was discharged as technical manager in Deutz, because he was so "indescribably thick-headed," and settled in Camstatt, that he developed the Otto engine to a motor "whose importance in the history of technology is equal to that of the first steam engine." By coincidence, the final German patent was awarded to Daimler for "a vehicle with a gas or petroleum engine" on August 29, 1885, and exactly five months later, on January 29, 1886, a German patent was granted Benz for "a vehicle with gas-engine drive." Gartmann comments, "Daimler's high-speed engine and Benz's motorcar provided the final impulse for the 'motorization' of world transport."

It was nearly a half century after the first work on the automobile engine that man's first motorized flight in the air took place in 1903.

Of course, flight itself was not new. Three out of four land creatures can fly. Of a total of some one and a half million known species of animal, roughly one million can move through the air. Yet the father of human air travel, Sir George Cayley, gave his classical definition of powered flight only towards the end of the eighteenth century, viz., "If it is desired to lift a weight by means of a surface, the resistance of the air must be overcome by the application of a force." After the thrilling adventures of the balloonists, and the dirigible airship, the first of which was built by Henri Giffard in 1852, and the most famous by Count Zeppelin, we come to the contemporary story of the airplane. But it is a commentary on human blindness and lack of the prophetic gift that, in 1901, H. G. Wells was "unable to visualize the important influence that flying would exercise on travel." And it is a dramatic story that fifty years before 1903, an American bishop by the name of Wright declared emphatically "men will never fly, because flying is reserved for the angels." However, in 1903, his sons, Orville and Wilbur, proved their bishop-father wrong! But of course, as Gartmann points out, fifty years earlier the Wright brothers could not have achieved motorized flight. By 1903 the time was ripe for it, but only when, in addition to the timing, there were patience, imagination, enthusiasm, energy, courage, determination—and a little luck. Further, unlike Langley, the great scientist who failed within ten days of the Wrights' success, the latter had what Langley did not have, viz., actual experience in flying. For they had made a thousand gliding flights in learning the secrets of flight.

In discussing the next field of communications, which the author entitles "The Invisible Net," he states that man's increasing need for information prompted an astonishing degree of inventiveness in the transmission of news. With emphasis on many men whose names are not well-known in America, as well as those who are, we are taken through the story of the cable and the telephone, with the trials and tribulations of their inventors. Many of his contemporaries thought that Bell would not have become the inventor of the telephone had he had a good technical education. The author thinks they were right. For Bell's success was not due to any skill as an electrical engineer, but to his knowledge of the human voice as a teacher of speech.

The developer of radiotelephony, on the other hand, was a good businessman and entrepreneur, who was in his field somewhat like Sir Richard Arkwright in textiles. Marconi assembled the discoveries of others from various nations, including the electromagnetic wave theory of Maxwell, an Englishman; the transmitter of Professor Hertz, a German; the coherer, invented by Branly, a Frenchman; and the antenna, invented by a Russian. During the First World War, the time was ripe for a fourth step in world-wide communication: public radio and television services with transmission of speech, music, and moving pictures. This brought in the work of Lee DeForest, the

prophet of radio in America, and the developments in Germany and elsewhere in Europe, in the face of opposition of those who could and would not see that technical achievements in broadcasting had any cultural value.

Success in the radio transmission of pictures came suddenly, with world fame, to a poorly-paid store clerk, John L. Baird in London, October 2, 1925, who transmitted an image of the head of "Bill," an old ventroloquist's doll, and then a stray office boy—the first televised picture of a living man. And it was made more practical by the genius of Vladimir Zworykin, in America, who invented the iconoscope in 1923—an electronic tube which is the heart of the television camera. By the 1940's television's struggle was over. Man the pleasure-seeker had won another round, and man the inventor could turn to new problems.

Regarding the revolution in physics of the twentieth century, the author tells with clarity and force the contemporary story of the new type of radiation, the Curies and radium, the splitting of the atom, the world-shaking discovery of nuclear fission, the making of the atomic and hydrogen bombs, the peaceful uses of isotopes, and the future technical possibilities for mankind in the atomic age. Until his death in 1937, even Lord Rutherford refused to believe that it was possible to use nuclear energy in practice. Likewise, Fermi reached a wrong conclusion at one stage and thereby postponed for four or five years the discovery of fission of the uranium nucleus with neutrons by the Germans, Hahn and Leitner, which filled them with excitement and dread. But even Hahn and Niels Bohr at first thought that it would have no practical application. Today we know differently. We know also that there is no end to innovation and revolution in science. There is always tension between the new and the old.

This is shown in the discussion of automation, which the author calls "the crowning achievement of technology," involving the amazing contemporary computers and their incredible activities. Yet they cannot really think. The creative faculties of man's intelligence can never be artificially imitated. But machines can exercise automatic control over production of goods. The first industrial revolution mechanized manufacture, replacing muscles by machines. This second industrial revolution is the automation of manufacturing processes, i. e., in taking the place of human beings, releasing them for other activities.

The final chapters on penetration into outer space and the race to the fixed stars, within and without our own galaxy, deal with the present race in putting rockets and artificial satellites into space—with the Sputniks, Vanguards, and Explorers—and speculation on where all this activity, spectacular and fantastic beyond the dreams of a Jules Verne, will end. It is an excellent record of contemporary space penetration enterprise carried on by able specialists in the employ of the American and Soviet governments. The most startling feature of this

discussion, unknown to the general public, forms the climax to the volume. It is the description of the theory of Dr. Eugene Sänger, a Stuttgart engineer, propounded in 1956 at Freudenstadt in the Black Forest, which precipitated the photon-rocket controversy. In his paper and pamphlet, "The Mechanics of Photon-Rocket Drives," and his subsequent lecture at the Seventh International Astronautical Congress in Rome, entitled "The Attainability of the Fixed Stars," Dr. Sänger showed by a masterly mathematical statement the theoretical possibility of jet space ships moving, relative to the earth, at a speed approaching and even exceeding the speed of light. The life of the crew would appear to the terrestial observer to be extended as the speed increased, and they would thus survive many generations of earth dwellers. One crewman's lifetime would suffice for a journey right around the universe, the ultimate in space travel. In view of the controversy, Pope Pius XII had the theory tested by the Vatican's scientific experts and decided that Sänger's conclusions were valid. A stimulating book for anyone!

RUDOLF A. CLEMEN *

Der Weg aus der Tretmuhle. Ein Abriss der Geschichte der Technik der Neueren Zeit. By Franz Hendrichs. Düsseldorf: VDI–Verlag, 1958. Pp. 236. 16 Plates. 17.20 DM.

The first edition of this book appeared in 1955. The present, second edition was revived, after the author's death in 1956, by Dr. Friedrich Klemm.

Franz Hendrichs was an engineer active in the steel industry, and his long interest in the history of the trade is documented in an earlier publication: *Die Geschichte der Solinger Industrie* (Solingen, 1933). The present book constitutes a sincere effort to describe in 177 pages the rise of modern technology from James Watt to Henry Ford.

Scholars acquainted with *A History of Technology*, edited by Singer, Holmyard, Hall, and Williams, where a shorter period (1750-1900) is passed under review in the 1500 pages of the two last volumes, will perceive the difficulties involved. A far too short introduction (40 pages) takes care of the history of technology from prehistoric times till the advent of the steam engine.

Hendrichs is not unaware of the tremendous task involved; he claims to write only an "Abriss," an outline, but perhaps for reasons inherent in the self-imposed limitation on the size of the book, he fails to place his material in true historical perspective.

* Dr. Clemen is Executive Vice-President of the Society of American Historians and has written widely on technological developments.

George Sarton in *The Study of the History of Science* (Cambridge, Mass., 1936), dedicated some very interesting remarks on the difficulties of dividing the history of science into intervals of equal importance. The constant acceleration of progress makes us believe that "real" science dates only from the seventeenth or sixteenth century and leads us to underestimate the efforts and achievements of the more remote past. This error of perspective is accentuated in the case of this history of technology, where apparently very little has been done before the so-called Industrial Revolution (ca. 1750-1850). Thus, the "road out of the treadmill" does *not* begin with Watt's steam engine, just as the history of nuclear energy does not start with Hiroshima.

For these reasons I cannot begin to point out all the important names and facts left out of Hendrich's book. As an introduction to the history of technology, the *Weg aus der Tretmuhle* has another serious deficiency: the lack of an adequate bibliography. The few publications cited are with rare exceptions German, and many of them deal with matters only indirectly related to the history of technology.

A special chapter is dedicated to the historiographers of technology, but only Smiles, Beck, and Matschoss are cited. If it is surprising that fundamental works belonging to the theme and times, like those of Abbott Payson Usher, Pierre Ducassé, Arturo Uccelli, Giovanni Canestrini, A. P. M. Fleming, H. J. Brocklehurst, etc. are not mentioned in Hendrich's book, it is even more distressing to observe the omission of the name of Franz M. Feldhaus.

The task that Franz Hendrichs had set himself was arduous but not impossible. That has been recently demonstrated by Dr. Friedrich Klemm, and it is very fortunate that his brilliant study, *Technik, eine Geschichte ihrer Probleme* (München, 1954), has recently been translated into English by Dorothea Waley Singer under the title *A History of Western Technology* (New York, 1959). (Cf. *Technology and Culture*, Vol. I, No. 2, [1960], p. 178.)

LADISLAO RETI *

* A chemist and chemical engineer in Sao Paulo, Brazil, Dr. Reti has done research and written numerous works in industrial, organic, and biological chemistry. His writings on Renaissance science and technology manifest his particular interest in Leonardo da Vinci.

History of the Milling Machine: A Study in Technical Development. By Robert S. Woodbury. (Technology Monographs, Historical Series, No. 3.) Cambridge, Mass.: The Technology Press, 1960. Pp. 107. Illustrations. $3.50.

The milling machine, in its developed forms, possesses such versatility that it is not easy to describe it in a few words. In order to distinguish it from the gear cutters and the machine tools in the horological trades, Professor Woodbury defines the milling machine as a "generalized machine tool in which metal is removed by a rotary multiple tooth cutter from a work piece secured to a table whose motion relative to the cutter is controlled by any combination of longitudinal, transverse, or vertical feeds." The spindle, carrying the cutter, may be horizontal or vertical. It is, therefore, possible to perform many different operations without resetting the work on the table of the machine. The wide range in the capability of the machine makes it difficult for the layman to understand its position as a machine tool. It is easier to think in terms of a single purpose mechanism than to appreciate a multipurpose mechanism equally capable of producing accurate single tools or an indefinite quantity of fully interchangeable parts. The present richly documented monograph is primarily concerned with the technical development of this machine. Its early history is closely associated with the development of interchangeable part manufacture for the armories, sewing machines, and bicycles. There is no attempt made, however, to sketch the influence of the milling machines on the development of interchangeable part manufacture. An accurate history of the milling machine itself is a necessary basis for the broader historical study, but the general history of interchangeable part manufacture should be pursued independently of any single machine tool or instrument of precision.

The earliest milling machines were made by Eli Whitney and a group of English gunsmiths, who had established a small arms manufactory at Middletown, Connecticut. The Middletown machine was in use as early as 1818; Whitney's machine about 1820. Whitney's machine embodied elements not found in the Middletown miller, and though there was probably some exchange of ideas between Whitneyville and Middletown, Whitney was probably not indebted to the English group for items of major importance. In 1823, Naysmith, in England, developed a milling machine which came into limited use.

The development of the primary potentialities of the milling machines required thirty-five or forty years of inventive effort by eight men of distinguished ability working with as many firms of arms manufacturers or machine builders. The culmination of this period of active work was the Lincoln plain miller of 1855 and Joseph R. Brown's universal miller of 1861. The Lincoln miller was limited to

rectilinear motions; the universal miller was capable of producing spirals and a variety of curves, or curved surfaces. Neither of these machines was capable of heavy duty work in its original form, but improvements in design extended their capacities to steam engine and locomotive work.

There was, also, a notable development of the cutting tools. The earliest cutters, like their eighteenth century predecessors, were in effect coarse files, which had been chipped out by hand. They were costly to produce and difficult to maintain. Although attempts were made to substitute toothed cutters as early as 1839, little was accomplished until 1850, but the positive achievement was Joseph R. Brown's patented rotary cutter of 1864. These cutters were easier to produce and could be sharpened by a simple grinding operation. After this step had been taken many types of rotary cutters were developed.

The reproduction of complex shapes had been achieved in wood by Blanchard as early as 1818, but the principles of his pattern turning lathe could not be applied to metals. The cams used to make the tool follow the pattern wore out too rapidly when working in metals. The hydraulic device invented in 1903 by Albee was not successful. In 1920, J. C. Shaw produced an electric sensing device which controlled a servo-mechanism. The decisive advance was the all-hydraulic tracer controlled milling machine invented in 1927 by J. W. Anderson. It was a short step from these machines to more comprehensive automation with electronic controls.

The history of the milling machines is interesting because it suggests the danger of any sharply teleological analysis. As it was a multipurpose mechanism, the ultimate achievement was not implicit in the early forms. Development involved a series of inventions of substantial importance. The record thus illustrates the interweaving of research and development. With care the major innovations can be separated from the developments of an essentially engineering character which added rigidity and accurate control of motion that made it possible to apply a particular model to heavier work.

The record also suggests a great difference in the financing problems in early and late stages of development. Capital requirements were small in the early stages, and large gains in productivity were quickly achieved. Relatively small funds with short time loans and internal financing would probably suffice for a substantial period. Economic analysis of this whole sequence of research and development would surely be rewarding.

ABBOTT PAYSON USHER *

* Dr. Usher, Professor Emeritus of Economics at Harvard University, is the author of *A History of Mechanical Inventions.*

Geschichte des Technischen Zeichnens. By Franz Maria Feldhaus. Second edition, revised and enlarged with the assistance of Edmund Schruff. Wilhelmshaven (West Germany): Franz Kuhlmann KG, 1959. Pp. 121, 90 figures and 5 colored plates.

This handsome volume on the history of technical drawing crams a wealth of information into its hundred-odd pages. But the first thing to know about this well-paced, at times vivid, and always engrossing book is how it came to be. German industrial firms often mark a business jubilee with a Jubiläumsschrift whose topic is related to the organization or its field. The firm of Franz Kuhlmann, manufacturers of drawing equipment, brought out the first edition of this book in 1953 to mark its fiftieth year as instrument makers. For that occasion, Kuhlmann commissioned Franz Maria Feldhaus, Germany's well-known and most prolific writer on the history of technology, to tell the story of the craft.

This second edition differs from the first by some rearrangement and augmentation of the content, recasting of the sentences into more sympathetic form, and omission of occasional first-person commentary. The new page make-up and ten additional pages have yielded a text increase of perhaps twenty per cent over the first edition. Edmund Schruff, a technical writer and former associate of the Kuhlmann firm, had, with Feldhaus, the revision under way at the time of Feldhaus' death in 1957.

The book is directed primarily toward giving the interested layman a good survey, but it also contains much of value for the professional. One wishes for an index, and notes with regret that six of the seven bibliographical items are Feldhaus'. However, one must not lose sight of the purpose of the book—to present to the layman a meaningful exploration of the many facets comprising the engineer's main line of communication, technical drawing. The book rolls over many topical roads and makes small excursions to the side. Because of the areas considered, it is unique, giving a notion of the whole story instead of getting lost in technical depth and detail for only a few fields.

An idea of the content and scope is best obtained by glancing at the divisions of the book, but justice can hardly be done to the range and wealth of ideas. Thus, "Earliest Times, Ancient Times and the Middle Ages" (8 pp.) roughs out the course of drawing from the ice-age cave-paintings through the graphic arts of Egypt, Mesopotamia, and Arabia to west European practice, commenting on media and tools. Attention is called to a device common to the civilized drawings, viz., that of showing important parts located in different planes swung into a single plane.

"Technologist's Professions" (5 pp.) remarks that in Homeric

Greece, art and technology bore the same name (and stigma?) instead of being placed in opposition at they are today. With the Romans all things that were built, from cities to engines of war, came under the concept of "architectura" (as with Vitruvius); the practioners–people of ingenuity and inventiveness–were called "architecti." We learn that Rome had an "engineering" school in 228, and that Harun al-Rashid founded a technical school in Bagdad in 807. The title of engineer appears in the twelfth century, its use spreading under the urgings of the Crusaders who needed military engineers to back and encourage their Faith. Leonardo da Vinci, that peculiarly gifted man, received an appointment as engineer, and perhaps set a style, for in later generations many who achieved fame as engineers and inventors came from the non-technical ranks of life.

"The Kinds of Technical Drawings" (27 pp.) relates that most ancient drawings were destroyed because of the religious opposition offered "graven images." Of those remaining, building plans predominate; the few machine drawings extant were interleaved with the building sketches frequently preserved in monasteries. Illustrated manuscripts dealing with machines follow the Gothic period, and some pictures are even frugally dimensioned. Da Vinci's sketchbooks represent a high point in illustration. The sixteenth and following centuries produced numerous printed works showing and explaining the devices and equipment then current. Various degrees of skill may be noted, especially in the attempts at perspective. A few detailed working drawings are found, e. g., the geometric construction of gear-tooth profiles, although the bulk of the illustrations set only general policy, leaving the details to be worked out by the constructor. The illustrations of Agricola's *De re metallica* reach another level, the details being shown separately, with the whole placed in the working setting. The fold-out is borrowed from medical books to show either a sequence of events or parts. In the nineteenth century machines are "prettied up" by fashioning the iron work after Gothic, Moorish, or baroque motifs. Valuable repositories of drawings are the patent offices; the Netherlands have drawings and prints (copies) from 1589. The loss of such drawings by fire (U. S. Patent Office, 1836) or by deliberate destruction of the "worthless" (outmoded) is remarked on.

The four pages on "Measures and Measuring" tell of the difficulties encountered in establishing units of linear measurements. Measuring lines, folding measures, and steel tapes give increasing accuracy. The need for precision leads to the Johansson blocks, and the need for duplicability creates national standards.

"Drawing Media and Prints" (9 pp.) recalls that the many media, the three most important were papyrus, parchment, and paper, with papyrus dropping out in the tenth century. The re-use of parchment, not only for new work but especially its ultimate destruction in the

gold-beaters' shops, was responsible for the loss of many drawings and manuscripts. Duplicates were made on transparent materials such as oiled parchment (1400), with tracing cloth appearing about a hundred years ago. Early duplicates were made by pricking through or using a colored backing and tracing over (like carbon paper) with scriber or dot wheel; light sensitive materials for duplication are somewhat over a century old, and dry-process duplication dates from 1923.

"Ink, Washes and Color" (3 pp.) gives something of the history of ink, including its preparation and use. Colored machine drawings occurred even in the illustrated manuscripts and often followed a system, using blue for iron, yellow for brass, etc. The Record Books of the Mendel Foundation at Nuernberg show the development of drawing and colored drawings for a span of four centuries (1388-1788).

"Drawing Pencils and Colored Crayons" (8 pp.) recounts that sticks or styli of wood, horn, ivory, and metal were used to mark on wax tablets. The Romans used pieces of sheet lead on parchment. Styli of lead, silver, and various soft metal alloys were supplanted by the black stone, graphite, sawn into thin sticks or slivers. Holders were devised, and fired graphite-clay mixtures provided for uniformity and the control of hardness. The mechanical pencil was an 1822 patent. Red and yellow ochres, in stick form, as slivers in a holder, or sometimes glued to wood, were much used for colored work.

"Erasing" (2 pp.) tells us that wax tablets were erased by smoothing with the blunt end of the marking stylus. Metallic markings on other media were mostly removed by scraping with a knife, although acid mixtures seem to have been used, at least on manuscripts. Emery powder was also employed, and dried bread crumbs were recommended in 1400. The rubber eraser, invented in 1770, gained slow acceptance because of cost.

In "Compasses and Drafting Instruments" (16 pp.), we find that today's compasses and dividers are but mechanically refined versions of those used centuries ago, no new principles being involved. Indeed, practically all of the instruments of today were known around 1550, even to such a detail as replaceable points. Straight-edges had as forebears the snapline, still used by carpenters and masons. Ruling pens, inside and outside calipers were used by the Romans; calipers had been known to the Greeks.

Boards, preferably of soft wood, had been drawn on directly for untold centuries ("The Drawing Board" [3 pp.]), and later formed the underlay for papyrus, parchment, paper, and linen. The early surfaces were more or less vertical, as from an easel support, but the horizontal position became necessary with the use of drafting instruments. After the introduction of paper, frames were used for stretching, with the paper held along the edges by bands or glue. Short nails with broad heads to fasten leather and fabrics date from ancient times,

but thumbtacks as such date perhaps from only the seventeenth century. The one-piece, stamped tack is an invention of 1880.

"Drafting Apparata" (7 pp.) tells of the aids that were devised to ensure greater accuracy, especially in coping with perspective and copying from nature. Among these were frames with a network of threads forming squares, devices with eyepieces, moveable pointers, and the like. For copying existing drawings, various reflected light apparata were devised, and, of course, the pantograph. The camera lucida, originally (1806) meant for landscapes, came to be used for technical drawings by 1830.

With "Horizontal and Vertical Boards" (2 pp.), we come to modern times, where the development of the parallel ruling straight-edges, and the even more recent drafting machine, has allowed the board again to assume a nearly vertical position. This is now a practical necessity because of the larger drawings needed for our enormous machine tools, ships, and aircraft; even a hundred years ago it was inconvenient to crawl over a horizontal board in pursuit of a big flywheel.

"Drafting Facilities" (17 pp.) traces the development of the drafting machine from its invention in 1884 by Koerner to the latest models of the firm of Kuhlmann. As part of a total installation, drafting boards must be discussed too: they may be more than five feet high and nearly 100 feet long. Kuhlmann builds, in addition to conventional drafting machines, the very useful "perspective machines." Such machines quickly and reliably produce perspective drawings (with arbitrarily chosen vanishing points) from the conventional plan and elevation views of orthogonal projection. Perspective drawings have always been difficult to make and are tedious and uncertain in their execution, but they are highly desirable since a layman—a customer, for example—can understand them. The book concludes with a bare page of epilogue which reviews the firm's history for the half-century of existence. It should be emphasized that this book is about the history of drawing—it is not a "commercial" for Kuhlmann.

It would have been of interest had there been a discussion, however short, of some of the new problems in drawing, such as the extremely versatile projection process. This has been adapted in several forms to the rough needs of heavy industry and in other ways to the precision demanded for cartographic work and the gear-grinding shop.

The serious student of technical drawing should also be aware of "Kulturgeschichte des technischen Zeichnens" by Alois Neduloha, to be found in *Blätter für Technikgeschichte*, Volumes 19-21 (Vienna, 1957-59). This three-part serial is not part of the Feldhaus references. Different in spirit, and with a bibliography of nearly two hundred entries, Neduloha's work covers much more en gros and en detail.

The firm of Kuhlmann is to be commended for having contributed such a splendid addition to the scanty literature on technical drawing.

An English translation of this book, under the title "The History of Technical Drawing," began appearing serially in the October 1960 issue of *Graphic Science*.

R. S. HARTENBERG *

Die Uhr, von der Sonnenuhr zur Atomuhr. By Anton Lübke. Düsseldorf: VDI-Verlag, 1958. Pp. 441, 476 plates. 124.-DM.

This luxuriously illustrated, well produced, and avowedly compendious history of clocks is also, most unhappily, badly arranged, unscholarly in its precision and technical apparatus, highly parochial in its heavy reliance upon German sources and examples, and blissfully unaware of the last few decades of serious study in horological history.

It is indeed a pity to treat even a fine collection of photographs thus, peppering them haphazardly through the book and providing them with inaccurate captions. Let us rehearse a few examples: Near the end, after all the modern "atom clocks," comes a plate showing a Double Horizontal Sundial (mistakenly called a Moondial) and a pair of nocturnals by Johann Adolf Hergett (mistakenly called Kergst). Near the beginning, and also on the dust jacket, is a zodiac plaque showing the signs (lacking Cancer and Scorpio) equally spaced in a circle. The only identification of this marble piece is a credit caption to "Historia Photos, Berlin," no site, no museum, and a false identification of the object as a sundial.

Along similar lines, a quite ordinary French survey graphometer is exhibited as a "graphometer-sonnenuhr" (fig. 72) and a dial of bronzed and silvered brass is said to be of gun-metal and nickel (fig. 67). A set of chinese polyvascular clepsydras for providing a constant-flow device is misinterpreted as a series of six one-hour vessels—as if each pot would not start working until the last had stopped (fig. 118). The old, highly unauthentic, and blatantly Victorian reconstruction of the Ktesibius waterclock is re-hashed (fig. 122), and the once controversial and now provenly false clock of Philip the Good is cited without comment as being from 1430 (fig. 329).

When one considers the text, it turns out that the pictures are by far the best part of the book. In such a monumental tome the reader might expect to find a seriously documented discussion of dials and clocks from technical inside or from the historical outside. He gets neither. The technical presentation is at an elementary level, and the antiquarian treatment is secondhand, taken without footnote references from the single page bibliography cited at the end of the book. The

* The author of numerous articles in the fields of kinematics and engineering history, Dr. Hartenberg is Professor of Mechanical Engineering at Northwestern University.

name index is married by misspellings, thus, Becquerell, Tyche de Brahe, Ougthred, Stradanua, Wheatston, *for* Becquerel, Tycho Brahe, Oughtred, Stradanus, and Wheatstone. A most disappointing volume.

DEREK J. DE SOLLA PRICE *

Heavenly Clockwork: The Great Astronomical Clocks of Medieval China. By Joseph Needham, Wang Ling, and Derek J. de Solla Price. New York: Cambridge University Press, published in association with the Antiquarian Horological Society, 1960. Pp. xv, 254. Illustrations, 71. $12.50.

This monograph is the first full study of clockwork in China in any European language. It is parallelled only by a Chinese paper which appeared in the *Tsinghua University Engineering Journal* in 1956, written by Liu Hsien-chou, who apparently began his investigations into the subject at about the same time as Needham, Wang, and Price. Their initial inquiry was also published in 1956 (in *Nature*, 177). In that same year they had the opportunity of meeting Dr. Liu at the International Congress of the History of Science, held in Florence, and of discussing mutual problems. The book under review thus is the result of a meeting of minds of those best informed; it goes further too than Dr. Liu's own investigation in that the early history of clock-making in other parts of the Euro-Asiatic continent is joined to that of China's. The many illustrations too are a substantial contribution.

The great name in the history of clockwork in China, or for that matter anywhere, is that of Su Sung (1020-1101), scholar, civil servant, sometime envoy to the court of the Khitan, and student of botany, astronomy, mathematics, and the calendar. By a curious circumstance it was on his mission to the north (China above the Yellow River was then occupied by the Khitan) that he stumbled on the fact that these "barbarians" had a calendar more nearly correct than that of his own people. It seems likely that this was due not to their own knowledge, but to the fact that—in their sack of 946 of the great city of Kaifeng (then the cultural and political capital of China)—they had seized the entire court, together with "artisans, maps and registers, astronomical charts, . . . water clocks, . . ." and other items of technical importance. With these "artisans" and their descendants and the equipment carried to the north, the Khitan may well have been better served than the Chinese overlords who set up the dynasty of Northern Sung (960-1126). However that may be, our hero on returning to the Sung

* Dr. Price, an authority on the history of scientific and precision instruments, is Professor of the History of Science at Yale University.

capital reported his discovery to his emperor who ordered him (in 1086) to make a model of an armillary clock. When this was done, with the help of an ingenious clerk who had studied mathematics and older methods of time-keeping, and the model approved by the emperor (1088), a full scale clock was constructed, important parts being cast in bronze. This instrument, housed in a tower over thirty feet in height, and surmounted by a large bronze power-driven armillary sphere, was erected in the palace in the year 1090. According to Su Sung's biographical sketch in the dynastic history:

> "A tower of three floors was built, having an armillary sphere at the top, a celestial globe in the middle, and wheels with jacks attached to the same machine, all made to turn by water-power without human intervention. When the (double)-hours and quarter hours arrived, the jacks came out to report them, and thus the positions and degrees of the stars and constellations (read from) the instrument showed no error of even a fraction of time."

During the next four years Su Sung wrote a book about his clock, including therein an historical sketch of earlier instruments and a mass of detail about his own, with illustrations. By great good fortune, in spite of the hazards of invasion and rebellion and fire, this work (first printed in 1172) has been transmitted through several recensions to our day. The clock itself suffered removal to Peking when the Jurchen in their turn sacked Kaifeng in 1126. It may have been kept running for some years thereafter (forty at least from the year of manufacture), but eventually its various parts wore out and no effort was made to keep it in condition. By the end of the century (1195) a fearful storm destroyed the whole structure. Neither the Jurchen in north China nor the Chinese in the south were able to recreate a comparable mechanism, though in the south especially several earnest attempts were made. Many decades later, however, another redoubtable figure in the history of science, Kuo Shou-ching (1231-1316), made for Kublilai Khan in the years 1262-1270 at least two great clocks with striking jack-work which depended on the principle of the water-wheel escapement. Previous clock-makers, including Su Sung, had astronomical instruments in association with their time-pieces. Kuo, however, seems to have been the first to confine himself to the "auditory and visual reporting of time." The dates are worth noting: it was not long before the first appearance of mechanical clocks "as such" in Europe.

Having both text and illustrations, our authors—with their combined qualifications—have been able to make sense out of many technical terms and produce a translation of Su Sung's important treatise. Not only that; they have also rendered into English several other pertinent descriptive passages of Su's time and later. With this knowledge they have been enabled to go backwards in time and tell of the successive contributions of many a previous inventor; notably, Chang Heng of

circa A. D. 140, first to use water-power for rotating astronomical instruments, I-hsing and Liang Ling-tsan (725), who devised the water-wheel link-work escapement, and Chang Ssu-hsün (975-979), who may have been the first to use the chain drive. Su Sung himself lays claim to the invention of a "diurnal motion gear-ring above the (vertical) transmission shaft," and later historians have concurred with him in this claim. After Kuo Shou-ching, though there was some tinkering with clockwork devices, no real advances are recorded. In the seventeenth and eighteenth centuries the Roman Catholic missionaries introduced European clocks, bringing native developments virtually to a standstill, although a shadowy memory of them lingered on both in China and in Korea.

The book closes with a brief history of horological developments in the Hellenistic, Islamic, and European world, and to some extent in India. By circa 1300 A. D. all the elements of the mechanical clock were known in Europe save that of the principle of escapement. This appears some time during the next six decades (Giovanni de Dondi in 1364 makes a drawing of it and says it is "common"). At that point clock-work in the West is born. Who transmitted the idea and how, we may never know. Suffice it to say that the century of 1250-1350 is one of (if not) the greatest in world history for the percolation of Chinese ideas and inventions to the Mediterranean world. Consider the following: the magnetic compass, the Cardan suspension, gunpowder, blast furnaces, block printing, playing cards, segmental arch bridges, porcelain, the idea of landscape painting, and certain practices in accounting and banking.

All that has gone into the making of this book fills me with admiration: its smoothly written text and clear translations, its abundant illustrations, its lively and pertinent notes, its full bibliography, index, and tables of Chinese characters, even its romanization (which is preferable, in my opinion to the one used in Needham's other volumes), as well as its format. But I am unable to go along with the authors' theorizing in the first part of the chapter on the "context of the inventions." Here we are presented with the notion that a principal reason for the invention of an exact timepiece was to keep track of the precise moment of conception of a possible heir-apparent. Lady secretaries were posted outside the imperial bedchamber to note down in their record books each liaison of emperor and empress or concubine. Only thus would the star positions be known. One may admit that the asterisms played a notable part in ancient China. But in the enlightened days of the eleventh century could they have influenced such men as Shen Kua and Su Sung and their imperial masters? Surely the needs of calendrical computation, which our authors also discuss in Chapter VIII, are of more importance.

L. Carrington Goodrich *

* Dr. Goodrich, an authority on the history of science and technology in China, is Dean Lung Professor of Chinese at Columbia University.

The House of the Double Axe: The Palace at Knossos. By Agnes Carr Vaughan. Garden City, N. Y.: Doubleday & Co., Inc., 1959. Pp. 240. Illustrations. $5.95.

Never before has the glamor of antiquity pulled so strongly at human heartstrings, to judge by the ever-growing stream of popular books about things of long ago and far away. Besides the flood of historical novels, the last three lustra have seen a spate of popular non-fiction works on archaeological and ancient historical subjects. We have had lives of archaeologists like Schliemann; works on the ancient Sumerians, Egyptians, Hittites, Kushites, and Easter Islanders; and books on vanished cities and ancient monuments, like those by Cottrell and the Schreiber brothers. In quality these books range from excellent to awful. This is one of the better ones.

Dr. Vaughan, Professor Emeritus of Classical Languages and Literature at Smith College, divides her book into two parts. The first, "The Great Discovery," tells of the classical legends of Crete, of Evans' discoveries and excavations, and of the details of the palaces at Knossos.

The second part, "Minoan Life and Customs," reconstructs the life of ancient Crete. Minoan technology plays a considerable part in the tale because of our almost total ignorance of Minoan history, politics, and literature. In the absence of any solid facts about these matters, we must make what we can of Minoan culture from archaeological remains. We can get some idea of costume and custom from works of art; trade we can trace by the distribution of pottery and other commodities; and technology we know from tools and other physical remains.

Among Dr. Vaughan's points are: Minoan sea power depended upon the forests of prehistoric Crete and declined when these had been destroyed. The streets of Knossos were laid out in a definite plan. Knossos had houses of four or five stories, like the later Roman *insulae*. Houses had windows with translucent panes. The standard heating and cooking apparatus was a portable clay firebox; there was no separate kitchen. A board game, apparently of the tiddlywinks family, existed. The famous sanitary system is described. An illustration shows a miniature litter or sedan chair.

One of my few adverse criticisms of the book is that the illustrations, while fine as far as they go, do not go far enough. Dr. Vaughan describes many art works at length. Her descriptions make the reader eager for pictures, but the objects are often not illustrated. A map or plan of the palace would also have been welcome.

A couple of problems are raised but not solved. Dr. Vaughan, calling upon classical literature, ascribes to the Minoans a cult of snakes as incarnations of ancestral spirits. She says: "In ancient Greece

barley, honey cakes, cheese, and milk were considered a serpent's favorite food." True, this belief existed. But no snake ever, of its own free will, ate any of these substances. All snakes are carnivorous and all (except some egg-eating snakes) eat live and moving food. Most small and medium-sized snakes the world over live on insects, frogs, lizards, and small rodents. If one put a snake in a cage with barley, honey cakes, and so forth, it would starve to death before touching any of them.

Then, if the snake's refusal of such food indicates that great-grandfather's ghost is displeased, great-grandfather must have been angry all the time. So how did such a belief survive in the face of adverse facts? Here is a minor puzzle for some classicist with zoölogical knowledge.

Dr. Vaughan also mentions that " circular trays, which have aroused speculation, may possibly indicate that the Minoans raised poultry." A photograph shows a clay egg stand, ten inches in diameter, with three short legs and six holes for eggs, presumably hard-boiled.

Now, the Spring 1960 issue of *Archaeology* ran an article (p. 40) by the late Alan J. B. Wace, entitled " A Mycenaean Mystery." This describes and illustrates several similar low circular stands from Mykenai. They are made of brick, ivory, and bronze. They have holes like those of the Cretan egg stand. Most have stumpy legs like the latter, although the bronze example consists of two parallel disks fastened together by four short bronze tubes. Dr. Wace suggested that these disks were miniature models of pieces of furniture, possibly offering tables of some sort.

Although it seems likely that these Mycenaean objects belong to the same class as that shown in Dr. Vaughan's book, the former are distinguished by their smaller size, only five to six inches in diameter. Any eggs placed in the holes of the Mycenaean disks would have to be those of a much smaller bird—a bird comparable to the American robin. Here is another problem.

Altogether, Dr. Vaughan's book is well suited to its objective of telling the general public about Minoan Crete and its material remains; it can be read with profit by the historian of technology as well.

L. Sprague de Camp *

* Mr. de Camp is the author of some thirty books—covering wide areas of fiction, science fiction, and non-fiction, the latter including several dealing with the development and management of inventions. His latest book is a novel, *The Bronze God of Rhodes*, which contains much information regarding ancient technology.

Studies in Early Petroleum History. By R. J. Forbes. Leiden, Netherlands: E. J. Brill, 1958. Pp. x, 199. 16 Plates. 32 Figures. 25 Guilders.

More Studies in Early Petroleum History, 1860-1880. By R. J. Forbes. Leiden, Netherlands: E. J. Brill, 1959. Pp. 199. 2 Tables. 36 Figures. 27 Guilders.

In the United States, the modern petroleum industry is usually considered to date from 1859 when oil was obtained from the first well deliberately drilled for this purpose. It was brought in by Edwin L. Drake (1819-1880) in Titusville, Pa. from a depth of 69 feet after 19 months of work. Prior to Drake, a former railroad conductor, wells had been dug by hand or petroleum had been recovered from seepages. Drake's foremost contribution, often unmentioned, was in the prevention of the overburden of clay and quicksand from filling in the drill hole. This he did by using pipe driven down to bedrock. Unfortunately, Drake did not patent the idea. Later, he became an oil commission merchant, an oil speculator, and finally died in poverty.

Even before Drake, there was an advanced industry, as for example the operation by the brothers Dubinin in Mosdol in the Caucasus. Here, they erected a refinery to obtain petroleum distillates; they changed black naphtha into white " for better burning. An iron still set in brickwork was used. From 40 parts of crude, they obtained 16 of " white naphtha." The condenser was a copper worm in a barrel of water. The still head had a removable top.

These eventful happenings were among those which helped lead to the rapid rise in the importance of petroleum in modern times. Before these milestones, however, petroleum had already undergone a long and exciting history. The story begins in ancient Mesopotamia where petroleum products were found in streams and rivers as a result of seepages. Professor Forbes has intentionally excluded the most ancient Babylonian and Egyptian history in this very interesting collection of essays. Happily, he has given this account in a previous major publication: *Bitumen and Petroleum in Antiquity* (Studies in Ancient Technology, Vol. 1, Leiden: Brill, 1955).

The first volume under review contains essays dealing with the medieval period and going up to approximately the middle of the nineteenth century. One essay, entitled " Ex oriente bitumen," is concerned with early Arabic times. Here the evidence points to a much larger and expanded usage of petroleum and bitumen than in antiquity. This was particularly for such new uses as flame throwers, grenades, and torches as well as a more refined employment in medicine and agriculture.

In a chapter on early speculation on the nature and origin of pe-

troleum, Forbes has gathered some significant material. In The *De re metallica*, Agricola claimed that the "cold of the seawater consolidates the liquid mountain wax from underwater springs to amber and bitumen. . . ." This explanation remained alive for many years. Also discussed are the speculations of Pierre Pomet (1694), F. Lachmund (1699), J. F. Henckel (1725), P. J. Macquer (1758), and others.

Most of the chapters are concerned with developments in the industry on the European continent, for example, the "font de l'oli" at Gabian, France. Further, there is a section on Eyrinis d'Eyrinis (eighteenth century) who rediscovered bitumen as an engineering material. Included are essays on the oil seepages of Hanover and Tegernsee (Bavaria), and the first oil wells in Europe (eighteenth and nineteenth centuries). With the increase of petroleum production in Europe, it was found necessary to advertise to increase consumption. This took place in the late fifteenth and early sixteenth centuries. Broadsides and pamphlets elaborated on the many fantastic claims made for its supposed medicinal properties. Forbes gives the complete texts of some of these published at Geneva, Nurnberg, Antwerp, and Tegernsee.

The discovery of petroleum in the New World is related in an account of 1526 by Oviedo y Valdés, which concerns the asphaltic seepage at Puerto Principe, Cuba. It was used for painting the hulls of ships. A short time later, seepages were found in the ancient Inca Empire, in present day Ecuador and Peru. Then came those of the Lobitos oilfields described by A. de Zarate who travelled in Peru from 1544-1551. After 1595, when it was first discovered there, asphalt was exported from Trinidad to Europe, as it was later on from the Barbados, West Indies.

A valuable and simplified discussion in the final chapter relates the development of the procedures in producing oil by the dry distillation of shale. Forbes points out that the rise of the shale oil industry is intimately connected with the revolution in lighting which occurred in this period. It may be of interest to note that this development began seriously with the demonstration by Pierre Ami Argand in 1784 of a new oil lamp with a circular tubular wick. The purpose of this novel construction was to allow an inner air supply as well as an outer one on the surfaces of the wick. The oil was supplied to the wick by gravity while the flame was protected by a cylindrical glass chimney.

More Studies . . . is devoted to an account of the different segments of the European petroleum industry from about the time Drake successfully completed his well (1859) to about the year of his death (1880). With the help of research carried on by European university chemists, the budding petroleum industry established some of its basic operations in the production of fuel oil, paraffin wax, gasoline, and asphaltic bitumen. In this period, many new uses were found for petroleum products. This second volume also contains discussions of

the composition of petroleum and the separation of its constituents for various uses, for lamps, wax candles, burners, bearings, roofing, and pavements.

One of the most important essays gives an account of the history of early chemical research in petroleum and its relation to some aspects of the development of the contemporary organic chemistry. In other chapters, Forbes treats of the historical significance of the work of Pierandrea Mattioli (sixteenth century) and Pierre Belon (sixteenth century), the use of petroleum products in war, early production of petroleum in Rumania, Galicia, and Russia, production of paraffin wax, better lamp oils, and a number of byproducts.

The illustrations and plates lend interest to the books. Of the two large folded tables, one is a chronological survey of work on the principle of sliding friction from Da Vinci (ca. 1500) to A. Morin (ca. 1835). The other is a comparative chronological table on Greek fire and gunpowder. Both are very helpful for a quick survey.

The author has admittedly written these two volumes as a series of essays, and so they betray a discontinuity from chapter to chapter. This is necessarily so because the details of petroleum history have barely been scratched. However, on the whole, the reader is left with a satisfactory appreciation of the industry from medieval times to the beginning of the modern period. Dr. Forbes has provided a rich framework both in the history of the theoretical side of petroleum history and in careful description of the completely new technical processes of the eighteenth century.

MARTIN LEVEY *

Social Change in the Industrial Revolution: An Application of Theory to the British Cotton Industry, 1770-1840. By Neil J. Smelser. Chicago: University of Chicago Press, 1959. Pp. xii, 440. $6.00.

One of our central concerns in the study of technology and culture is the problem of social change. To ask how technology and culture are related is often to ask implicitly or explicitly such questions as: which changes the other? under what conditions? are the changeful processes one-sided or reciprocal? Because of their concern with the general problem of social change, many readers of this journal will entertain an immediate interest in the topic of social change in the Industrial Revolution, with especial reference to the British cotton industry, 1770-1840, which is the subject of a masterly book by Professor Neil J. Smelser of the Department of Sociology, University of

* Dr. Levey, author of *Chemistry and Chemical Technology in Ancient Mesopotamia*, is in the Department of the History of Science and Medicine, Yale University.

California, Berkeley. Professor Smelser's book is the product of his tenure of a Rhodes Scholarship at Magdalen College and of a Junior Fellowship at Harvard. Directly oriented to a newly developing body of technical sociological theory, that which is being created chiefly by Professor Talcott Parsons of Harvard, and based on several years of intensive historical research that has been acclaimed by specialists, this book introduces a distinguished new member of the scholarly world.

It must be said right away that this is not an easy book to read. As his subtitle indicates, Professor Smelser is here working out an *application of theory* to a particular historical case, and his interest in the theory is at least as great as his interest in the case. This means that in addition to its impressive historical documentation, the book contains a good deal of highly abstract, systematic sociological analysis couched in novel, though precisely defined and used concepts. Nevertheless, in part because Professor Smelser has made some effort to translate and to separate the more abstract references and implications of his theory from its specific application to historical data, the serious reader will probably be able to follow the argument and judge its usefulness for himself. This is especially true when, in Chapter XIV, Professor Smelser compares his own analysis of changes in the system of industrial production and in the family structure with four competing accounts of the same matters: (1) the "economic" explanation which refers social turmoil to wage and welfare conditions; (2) the Marxist explanation in *Capital*; (3) the approach of the "British Socialist" school; and (4) the approach of the revisionist laissez-faire historian, W. H. Hutt.

The essence of Professor Smelser's theory is that one important kind of social change occurs through a process of *structural differentiation* which comprises a *sequence* of seven steps or stages, each following the other in a necessary order. His fullest description of this sequential process can be found in the Introduction, but he has characterized it much more briefly in the following way: "dissatisfaction, disturbance, handling and channeling, encouragement of ideas, attempt to specify new social units, attempts to establish new social units, and routinization of established units" (p. 384). It should be carefully noted that one of the virtues of this sequential process as an explanatory model is just that it is not a *list* of factors, events, or steps which somehow or other account for a social change, but rather is a determinate sequence in which each stage is a prerequisite for those that follow because of fundamental sociological and psychological conditions of human behavior. It should also be noted that another virtue of this explanatory model is that it is said to be applicable to any social system whatever. In this book, Professor Smelser has applied it to only two aspects of the Industrial Revolution in England, the cotton industry and the family system. He thinks it would be equally instructive if applied to "other

instances of structural differentiation—the segregation of education from religion through a process of secularizing the schools; the segregation of political parties from the system of aristocratic family cliques; the segregation of the military and civil service from the earlier system of political and class patronage, and so on" (p. 408).

Unfortunately, there is little space here to illustrate the empirical usefulness of Professor Smelser's analytic model. Perhaps it will barely suffice to point out that the model meets one test which we often use to judge a new theory, the test of explaining a surprising, anomalous, contrary-to-"commonsense" fact. At one stage of the Industrial Revolution, it surprisingly appears, the cotton-factory operatives themselves opposed the factory legislation which was intended to help them and their children. At another stage, such legislation was welcomed, and Professor Smelser's model successfully accounts for this change of attitude as well as for the previous opposition.

It will, of course, be obvious from what I have written that this is not a book for everyone. I hope it is equally clear, however, that it certainly is a book for everyone with a specialized interest either in the general theory of social change or in an explanation of the origins and evolution of the Industrial Revolution.

BERNARD BARBER *

Charleston's Sons of Liberty: A Study of the Artisans, 1763-1789. By Richard Walsh. Columbia: The University of South Carolina Press, 1960. Pp. xii, 166. Illustrations. $4.25.

A review of this helpful monograph should perhaps begin with a statement of what it is *not*. Professor Walsh has not been primarily interested in the economic, institutional, or technological dimensions of Charleston craftsmanship in the Revolutionary period. Although he suggests that the question of the industrial and social contributions of the artisans is a significant one, his attention turns elsewhere. In a sense this is a pity, for his findings point to some modifications in the view of southern artisans taken by Carl Bridenbaugh in *The Colonial Craftsman*, an outstanding recent study. Walsh, for example, shows that it was easier for the successful mechanic to acquire land and begin the move into the planter aristicracy than has been supposed; and he implies a somewhat higher standard of craftsmanship among the South Carolinians than did Bridenbaugh. Walsh is familiar with Bridenbaugh's work—indeed his own is to some degree an extension and elaboration of one aspect of the earlier study—but his emphasis is

* Dr. Barber, Associate Professor of Sociology at Barnard College, Columia University, is author of *Science and the Social Order*.

upon politics. One consequence is that his delineation of the artisan class, with its various economic and social components, is less clear and comprehensive than it might have been. Thus craftsmen, "manufacturing craftsmen," tradesmen, artisans, merchants, and mechanics are not always clearly distinguished from or equated with one another. Here Bridenbaugh has provided a basis for analysis which might have been pursued with profit for our understanding of an important social class and of its shifting, and occasionally diverging, political interests.

For it is with politics that Professor Walsh is largely concerned. And for the most part his narrative moves effectively and his judgments are clear and convincing. Together with planters and merchants, the artisans of Charleston formed one of the three major interest groups of the colony. Under-represented, when represented at all, in town and colonial government, they had political grievances as well as economic for which the Revolution provided at least partial solutions. Under British mercantilism they faced unequal competition with the favored producers of the metropolis, while as debtors, together with the planters, they suffered from imperial tight money policies and taxes which drained off currency from the colonies. The basis was thus formed for a sometimes uneasy alliance of planters and mechanics which supplied leadership and power for the radical movement in South Carolina during most of the Revolutionary era. In this connection Professor Walsh finds that competition with slave labor was less severe than has sometimes been asserted; artisans themselves frequently owned and used slaves to supplement their meager labor supply.

Even before the Stamp Act the mechanics had begun to organize politically through the John Wilkes Club. Non-importation as a politico-economic weapon had obvious attractions for colonial artisans; and when British policy made such measures popular they were able to carry the day for this and other limited assistance to local manufactures. When the Tea Act added dissident merchants to the party of protest, the mechanics and their allies came into their own; and Charleston had its own "tea party," Southern style. Thereafter, events to the north dominated political developments. Legal government came nearly to a standstill, and a General Meeting of the inhabitants, dominated by the radicals and acting through a General Committee, assumed de facto rule. On a vote to forbid the landing of horses in March, 1775, in accordance with the Articles of Association, the mechanics' party won by a single vote. Then came Lexington, war, inflation, "defense industry," and constitutional reform.

In an interesting chapter Professor Walsh recounts the problems and persecution of the radicals during the British occupation of Charleston from 1780 to 1782. Some artisans held out at considerable cost to their persons and property; but others, as might be expected, yielded through pressure or desire for profit to collaboration with the British. Originally the occupying authorities planned to use the artisans for

their own purposes, but this idea fell afoul of radical non-cooperation and opposition to "a kind of factory system" which Professor Walsh mentions merely in passing.

In the post-war years, the planter-artisan alliance fell apart over the issues of hard money and competition with slave labor. Mechanics and some merchants found themselves in a new league against the old aristocracy of wealth and land. Appropriation of Tory property, regulation of wage rates, and the encouragement of manufactures were among the issues often violently in dispute. Peacetime conditions enlarged upon differences of interest among the artisans themselves.

Other interesting post-war developments included support by Charleston artisans for the creation of a stronger central government in order to protect local manufacturers, the gradual loss of political and social influence by the mechanic class, and the emergence of mechanics' societies and a rudimentary labor movement. Had Professor Walsh's frame of reference been a little wider, the significance of these events might have been more thoroughly explored. Within his chosen limits, however, he has produced an illuminating and useful study.

MORRELL HEALD *

The American Civil Engineer. By Daniel H. Calhoun. Cambridge, Mass.: The Technology Press, 1960. Pp. 295. $5.50.

With the appearance of this book we have the first thorough and specific study of the beginnings of the civil engineer in America—of his origins, his work, duties, and obligations, and of his social and political stature in the formative years of our Republic. Mr. Calhoun examines the careers of those engineers who worked on internal improvements, mainly canals and railroads, during the period from 1770 to 1850. From primary source materials he has uncovered the work experience of these men—their employment by private corporations and state governments—their salaries, their numbers and distribution, their status and ranks.

Chapter one, entitled "Before 1816," demonstrates that engineers at this time had little in common, except that they all had something to do with directing public works. Their occupations, their backgrounds and training, their methods and procedures varied. Before 1816 the engineer as a distinct type had not yet appeared. It is interesting to realize the dearth of engineers or quasi-engineers. In any year up to 1816 they never averaged more than two per state.

* Dr. Heald is Chairman of the Department of Humanities and Social Studies at Case Institute of Technology and is the author of articles on the history of American business policies and practices.

The second chapter, "Creating an Engineer Supply," tells the story of the New York State Canal System, which has always been regarded as the first source of American-trained engineers. Its importance was great, but the author points out that West Point equaled the New York Canal System as a supplier of civil engineers, at least by the early thirties, and far exceeded it by the late thirties. West Point graduated its first civil engineer in 1818. Other early engineering schools were Alden Partridge's School, Rensselaer Polytechnic Institute; some other institutions—such as Hanover College, Indiana, the University of Michigan, and the University of Virginia—offered courses in civil engineering. But the pattern of apprentice or on-the-job training persisted. In 1837 the American civil engineering profession consisted mainly of men with no school training as engineers, so that, in origin, they were creatures of the organizations for which they worked.

But it was these organizations, or the men who directed them, which helped to determine the occupational characters of the American civil engineer. Chapter three, devoted to a description of the tasks of the engineer, is in many ways the most interesting one. Mr. Calhoun recounts the steps taken by an engineer on a typical project. Among the tasks were overseeing the contractor—contracting was not a typical function of the engineer—promotion work, making executive decisions and functioning in an owner-management role, consulting, and designing and building construction machinery.

In the section on contractor-engineers, Mr. Calhoun quite rightly points out that at first bridges were often executed by these men. But he proceeds to say that bridge-building practices "for at least a generation beginning about 1820 excluded engineers from more than routine tasks. Bridges of sufficient span to constitute significant technical problems were increasingly built according to one of a few proprietary designs available for timber bridges, chiefly that of Ithiel Town patented in 1820 and that of Stephen H. Long in 1830. While the engineer of a project might decide which type of design was to be used, actual execution involved only the payment of royalties to Town or Long and the assignment of construction to a carpenter-contractor." What Mr. Calhoun means by "routine tasks" or by execution which involved only the payment of royalties I am not sure: actually bridges, whether built of Town Lattice trusses, of Burr truss-and arch type, of the Howe truss, or even of simple King and Queen Post trusses, offered greater variety and novelty in construction than Mr. Calhoun seems to think. This point, however, is a very minor one and unimportant to the thesis of the book.

We next meet two eminent Massachusetts engineers of the period—Loammi Baldwin the younger and John Langdon Sullivan; then Benjamin Wright, principal engineer of the New York Canal system. Chapter four introduces us to the B. & O. engineers from 1827-1838, who demonstrate the thesis that the "old," individualistic engineer

was giving way to the "new" organization engineer. This type is exemplified in men like Caspar Wever, Jonathan Knight, young Benjamin Latrobe.

The rising fortunes of the civil engineer seemed blocked from 1837 into the 1840's by economic panics and depression. Retrenchment needs caused much speculation about the status, activities, and worth of civil engineers. Probably the most interesting debate that arose was the idea of the practical, empirical man *versus* the scientifically trained engineer. The Whigs supported the latter type; the Democratic spokesmen the former. I cannot refrain from quoting here a passage written by Charles B. Shaw, in 1836, then the Virginia state engineer:

> An engineer who may have the misfortune to be scientific, is continually under necessity to vindicate his specifications from the self-claimed 'common sense' of superintendents anxious to execute some little change devised by themselves.

The final chapter deals with the official recognition of the civil engineer as a distinct occupational and professional group. In 1839 American engineers made their first attempt to organize on a corporate basis. But the early attempts were abortive; it was not until 1867 that the American Society of Civil Engineers was finally formed. In the meantime the engineer had become an organization man, a respectable member of a bureaucracy; he had allied himself with the gentleman, the professional man, and—most important—he had become a true scientist. In sum, "it was not a Jeffersonian America but a Corporate America that supported the engineer, sustained the engineer, and quite early defined his character."

Although this book is not for the casual or general reader, it will be of vast interest and use to the serious student of the history of American Engineering, of American history, or of American sociology. Mr. Calhoun has done well a job that needed doing; he has explored virgin territory and found it rewarding.

Sara Ruth Watson *

* Dr. Watson, Professor of English at Fenn College, teaches a course in the History of Civil Engineering. She has written widely on topics in the history of engineering.

Colt: The Man, The Arms, The Company. By James L. Mitchell. Harrisburg, Pennsylvania: Stackpole, 1959. Pp. 265. Photographs. $10.00.

Approximately a dozen books have been published about Samuel Colt and his Connecticut arms works since the inventor's death in 1862. Six have appeared within the past quarter of a century, three in the form of biographies. The rest concern a particular aspect of Colt's career and the empire which he constructed.

This latest volume does not seem to fit any particular category, but is a miscellaneous assortment of letters (1846 to 1862), photographs, and observations. Perhaps collectors of books on firearms welcome its appearance, but this reviewer could find little to commend it to the historian or the general reader except the beautiful engraved plates and excellent quality of paper. Otherwise, the only thing that holds the contents together is the binding.

This latest work does contribute fresh information on some minor phases of Samuel Colt's career. The first series of letters presented were written at the outbreak of the Mexican War. They reveal Colt's unsuccessful efforts to obtain a commission in various state militias and to command a regiment armed with his repeating rifles. His motives apparently stemmed more from a desire to popularize his rifles, and thus obtain lucrative government contracts, than from any great sense of duty to his country. Later, he placed several dozen pistols in the hands of Commodore Perry as gifts for the Japanese Emperor. The gesture resulted in a letter of thanks from the Emperor, but no orders for guns. Instead, the Colt models were copied by the Japanese without benefit of royalties to the donor.

The author presents other examples of Colt presenting pistols to local celebrities and foreign dignitaries, and his offer to furnish arms without cost to the Government if necessary. The point is made several times that the inventor, in his entire career, never gave any arms without expecting returns beneficial to him. This included gifts and sales of arms to the Confederacy on the eve of Fort Sumter. The outbreak of war between the states, however, finds Colt engaged exclusively in the manufacture of arms for the North. Though he was not the first to fulfill his contracts to the Government, the author maintains that the quality of Colt's muskets, rifles, and pistols was superior to those furnished by competitors.

Generally, the material is badly managed; the letters and documents put together to form particular chapters often do not fit into a central theme, and the author's effort to relate their content to his own narrative falls far short. The repeated use of the transitional phrase "it is interesting to note" becomes overly tiresome. And such paragraphs as the following often bear no relation to anything: "On May 16 Amos

H. Colt formerly his representative who traveled through the South drumming up business shortly prior to the Civil War was commissioned 1st Lieutenant. On May 19 his nephew Samuel Colt was also commissioned 1st Lieutenant."

It is hoped that the next time the Stackpole Company publishes an expensive book of this sort, that it will balance its effort with reasonably good editorial assistance.

W. Eugene Hollon *

Yankee from Sweden: The Dream and the Reality in the Days of John Ericsson. By Ruth White. New York: Henry Holt & Company, 1960. Pp. xix, 299. Illustrations. $4.50.

In a lively and fluently-written book of medium length, Mrs. White has furnished us with the first life in English of John Ericsson (1803-1889), inspired builder of the *Monitor*, since William Church's two-volume work of 1890.

Colonel Church, founder and perennial editor of the *Army and Navy Journal*, was Ericsson's friend and chosen biographer. He used the several thousand letters that Ericsson wrote to his solicitor and confidant, John Sargent, which now form the bulk of the Ericsson papers in the American-Swedish Historical Foundation Museum, and quoted at length from many of them. While the result was an account that included nearly all the episodes of the Ericsson story, it was understandably uncritical and tedious. The present work, based upon much additional research, tells essentially the same story, but in a vastly more readable way. The author's insights into Ericsson's character are considerably sharper than Church's; like Church, however, Mrs. White presents the well-known but implausible picture of Ericsson as an unhappy scientific and practical genius, doomed to inhabit a world not yet ready for him. Thwarted at nearly every turn by stupidity, prejudice, and opposition to change, Ericsson is pictured as one who forged relentlessly forward, giving the world one great fundamental idea after another. While the ideas were seldom accepted at the time, they became—if we are to take the story at face value—the very basis of later technology. His long list of unsuccessful enterprises and machines inclines me toward a different conclusion. The author has, however, recognized one of his outstanding attributes, his "resurgent power to soar above the dying fires of burned-out hopes and brilliant schemes."

* Professor of History at the University of Oklahoma, Dr. Hollon is author of *The Lost Pathfinder, Zebulon Montgomery Pike; Beyond the Cross Timbers, The Travels of Randolph B. Marcy; William Bollaert's Texas*; and *The Southwest Old and New.*

Ericsson was born in Sweden in 1803 and at the age of 11 became a naval cadet, assigned to the construction of the Göta Canal. At the age of 14 he was, we are told, placed in charge of 600 men. At 23 he went to England to demonstrate his newly-invented air engine. There events followed a pattern that was to be repeated many times throughout his life: the engine worked perfectly in Sweden but because of some trivial circumstance (in this case the substitution of English seacoal for Swedish pine shavings as fuel) it failed its English trial. His steam fire engine was rejected in London because it took too long to fire up and it threw too much water. Ericsson's entry in the 1829 Rainhill trials of locomotives, the fleet but hastily built "Novelty," was rejected because of the prejudices of the judges, the yielding of joints in its boiler, and the performance of George Stephenson's "Rocket." His propeller-driven steamboat, the *Francis B. Ogden*, was rejected by the pompous Lords of the British Admiralty, who did not understand what they had seen.

Coming to the United States at the age of 36, he carved out a precarious living with the expenditure of prodigious energy. His steam propellor ship *Princeton* was embraced and later rejected by U. S. naval officialdom. The *Iron Witch*, a paddle steamer built in 1845 for Hudson River service, was not fast enough to compete with other paddle steamers. In 1853, he promoted the construction and trial of the abortive caloric ship *Ericsson*, whose huge main engine, probably the largest (in displacement) reciprocating engine ever built, before or since, was of his design.

From the ashes of his enormous caloric engine rose one of his successful undertakings. Small air engines of Ericsson's design were built and sold by the thousand, providing a convenient and safe, though inefficient, small power source. His success in selling, building, and delivering at precisely the proper moment the *Monitor* is certainly genuine. The *Monitor* had a tremendous immediate effect upon naval warfare; its long range effect has not yet, to my knowledge, been studied critically.

The success of his *Monitor* did not slow Ericsson's prodigious output of new schemes and ingenious machines. For another 27 years he continued to work at top speed, pausing only long enough to reply to some of his critics and detractors. In the end, his honored body was returned to Sweden in an American naval cruiser. Years later a statue was erected to his memory in Washington. Even here, however, the story took a typically ludicrous turn when, during the congressional hearing on the bill authorizing the statue, an elaborately prepared and quite preposterous claim was submitted to show that Theodore Ruggles Timby, not Ericsson, had invented the turret and was therefore responsible for the *Monitor's* success.

If any engineer ought to have a full, balanced, and plausible biogra-

phy, John Ericsson surely merits one. In my opinion, this book does not do the job.

However, having tried to unravel the story of but one incident (that of the caloric ship *Ericsson*) in his long life, I am keenly aware of the time-consuming effort involved in separating fact from legend and in assessing his contributions to the mainstream of engineering progress. As if to insure the impossibility of the task of writing a satisfactory biography, Ericsson ordered the destruction, three years before his death, of 75 volumes of his notes and two large wagon loads of his drawings (superbly executed, beautiful drawings, judging by the few that survived). The notebooks, he said, were a record between himself and time, with which the public had nothing whatever to do.

The attempt at a definitive biography will have to be made by someone (I know not how to say this gracefully) who understands the engineering disciplines involved in Ericsson's work. The quoting of authorities, contemporary and modern, is no substitute. For example, the author's justification of Ericsson's regenerator of 1853, which embodied the "grand principle" of his caloric engine, by comparing it to the regenerator in a 1957 gas turbine ship, is caused by an engineering authority's jumping to an unwarranted conclusion, which engineers have a way of doing when they dip lightly into history.

I shall only quibble about the absence of footnotes; about the meaning of the author's statement that while "some scenes in which John Ericsson appears have been imagined, they have not been fictionized"; and about the four errors that occurred in copying Ericsson's list of his achievements from his book (Appendix B).

I am more disturbed, really, by the lack of supporting evidence for Ericsson as a "theorist lost in the poetry of mathematical abstractions" (page xvi). Mathematical theory is suggested also on pages 61, 70, and 202. I have the impression that his use of mathematics was rudimentary and that his theoretical knowledge was quite limited; this may be a more plausible explanation of his "splendid failures" and "brilliant failures" than blind prejudice and bitter opposition to "the lone inventor who broke time-honored, sacred rules."

John Ericsson is, as the author points out, a controversial figure. He would be much less so if we had more dispassionate information upon which to base our judgment of an apparently gifted and certainly complex character.

EUGENE S. FERGUSON *

* Mr. Ferguson is Curator of the Division of Mechanical and Civil Engineering of the Smithsonian Institution.

Nineteenth Century Glass: Its Genesis and Development. By Albert Christian Revi. New York: Thomas Nelson and Sons, 1959. Pp. xviii, 290. Illustrations. $8.50.

So all-embracing is that classic among cookery books, *Household Management*, that it is, perhaps, not surprising that the overwhelmingly thorough Mrs. Beeton should have been (quite erroneously) accused of beginning her recipe for roasted hare with the injunction "First catch your hare." Yet Mr. A. C. Revi, of Dallas, Texas, whose book *Nineteenth Century Glass* is such a welcome contribution to the history of glass making and decorating from the technological and artistic viewpoints, probably feels that Mrs. Beeton should have started as legend has it, for it would appear that before setting about writing his book he took the precaution of building up an enviably comprehensive collection of the nineteenth century glass about which he intended to expound. For those in a position to do it—and Mr. Revi must have dipped deeply into his pocket, for many of the items in his collection are museum pieces—this fundamental approach to authorship is to be commended. But Mr. Revi's book is no mere catalogue of his collection, though, in fact, a large proportion of the illustrations are of pieces in his possession. It is, indeed, a considerable work of scholarship concerning a range of ornamental glassware which has hitherto received scant attention, and students and collectors are in his debt for undertaking so detailed an investigation into a subject which is likely to be of increasing interest with the passage of years. Some of the fruits of Mr. Revi's research have been published in American periodicals, but now the public is presented with a handsomely produced and lavishly illustrated work which, if it does not constitute the last word—and what does?—on the subject, has the distinct merit of introducing in a concise and straightforward way a fascinating field of study.

The first criticism to be directed at Mr. Revi is his choice of title—*Nineteenth Century Glass*—for the types of glassware with which he deals were produced almost entirely in the last quarter of that century. The reader who expects to find data on the finely cut products of the Stourbridge and Irish factories, on the early pressed vessels made by the Boston and Sandwich Glass Co., or the mould-blown whisky flasks and pressed commemorative cup-plates beloved of American collectors, will be sadly disappointed, for these products of the first half of the century are completely ignored. Though his title undoubtedly is misleading, Mr. Revi can be forgiven for omitting lead crystal and the cheap pressed and moulded ware, for already there is an enormous literature about this, and he is able to devote all his energy and space to lines which have not previously received their due. To twentieth century eyes many of the styles of glassware which receive his atten-

tion will appear garish and crude in design, but technically they are very considerable achievements, especially when it is borne in mind that the application of strict scientific method in glassmaking was rarely practised with any degree of efficiency. For his facts about the recipes for the glasses Mr. Revi has gone to a source which in the past has been inadequately tapped by historians, namely, the records in the Patent Office. One feature that emerges clearly from his investigations is the extent of the enterprise shown by glass manufacturers in trying to satisfy a novelty-craving market. No shape however contorted and no combination of colors and curious effects was too elaborate or florid for them; and, truly, some of their products were so fantastic that one wonders what sort of aesthetic values obtained at the time that people should desire to possess such articles. Good though many of the pictures of these pieces are, without color it is impossible to convey fully what monstrosities some are. The colored picture on the dust-jacket of a furnace-decorated two-handled bowl adorned with fruit and leaves indicates how much is lost by having only half-tone plates, but to provide accurate color would have made the book prohibitively expensive.

Mr. Revi reveals that one of the most important figures in the decorative glass industry in the period with which he is concerned was Joseph Locke, an Englishman born in 1846, who early in his career was employed by Hodgetts, Richardson and Co. of Wordsley, one of the largest and most enterprising of the Stourbridge group of glass manufacturers. This firm was in due course joined by Philip Pargeter, but then the partnership was dissolved; Pargeter continued as proprietor of the Red House Glassworks, and members of the Richardson family operated another works a stone's throw away. The subject of the keenest rivalry between Pargeter and Richardson was the production of a replica of the Portland Vase, which is probably the most famous piece of glass in existence. After much experimentation directed by Pargeter, a satisfactory blank of the vase was made at the Red House, and John Northwood, a skilful engraver, was engaged to carve the cameo-style design out of the white layer of glass. It was a patience-testing task which occupied three years, but in 1876 Pargeter's replica was completed, though, alas, in the final stages the vase cracked. This replica was in April, 1960, placed on loan to the British Museum by Mrs. E. M. Duffy, of London, a member of the Pargeter family. Meanwhile the Richardsons had also produced some blanks of the vase, and Joseph Locke proceeded to carve the relief decoration. The Richardson-Locke replica was awarded a gold medal at the Paris Exhibition of 1878 and is now in Mr. Revi's collection.

Locke had made a reputation and in 1882 he went to America, no doubt taking with him much information about colored glasses he had been able to glean at the Wordsley glassworks. He found employment at the New England Glass Works at Cambridge, Massachusetts, where

his inventive genius was allowed full play. Amberina, which he patented in 1883, was probably his most important colored glass discovery. Many variations of this glass were produced either under new patents or under license in the United States and England. For instance, Edward Libbey obtained patents in 1884 and 1886, and the Libbey Glass Co., of Toledo, made Amberina up to the turn of the century. Pressed Amberina and Painted Amberina enjoyed brief periods of popularity. Locke also patented Agata and Pomona Glass and became one of the outstanding glass technologists of his day. If, as Mr. Revi claims, the nineteenth century was the Golden Age of Glass, then Joseph Locke must be acknowledged as one of the brightest stars of that Age. Another was Frederick S. Shirley who in 1885 patented Burmese, a type of glass in which oxide of uranium was used; specimens of it are now much coveted by collectors. Among the other kinds of colored glassware with which Mr. Revi deals so competently are Pearl Satin Glass, originally patented in 1858 by a distinguished Wordsley manufacturer, Benjamin Richardson, as "An improvement in the manufacture of articles in glass so as to produce perculiar ornamental effects"; Coraline, which was made by several English and Continental manufacturers and at the Mount Washington Works, New Bedford, Massachusetts; Alexandrite, made about 1900 by Thomas Webb and Sons, Dennis Glassworks, near Stourbridge; Royal Flemish, made by the Mount Washington Co.; Aventurine Glass; Peloton Glass; Silveria, made by Stevens and Williams, Brierley Hill, Staffordshire; silvered, silver-deposit, iridescent glass, spun glass, cameo glass and cameo incrustations, Crown Milano and Albertine, enamelled glass, threaded and flashed glass, millefiori—indeed glass in an almost infinite variety. A wealth of information is supplied about these, and in addition the book has an informative but somewhat disjointedly composed introduction, a glossary of glassmaking terms, and an index. On the debit side it should be pointed out that there is a disconcerting profusion of slips in spelling which more efficient proof-reading should have removed, and it is a pity that Mr. Revi has not provided the registration numbers of the patents mentioned, detailed references, and a bibliography.

H. J. HADEN *

* H. Jack Haden, English journalist, is an authority on glass and ceramics. He is the author of *Notes on the Stourbridge Glass Trade*, a contributor to the *Journal of the Society of Glass Technology*, and Stourbridge correspondent of *Pottery and Glass*.

Salt and Salt Shakers. By Arthur G. Peterson. Washington, D. C.: Washington College Press, 1960. Pp. 148. Illustrations. $5.00.

The present book is an outgrowth of Dr. Peterson's hobby of collecting glass salt shakers which were produced in a great variety of sizes, shapes, and colors in the last quarter of the nineteenth century. He states that the term "salt shaker" did not come into widespread use in the United States until the 1890's, when it began to appear in the large mail-order house catalogs, which, incidentally, should be a valuable source material of the evolution of domestic household appliances, tools, furnishings, and apparel.

A brief history is given of the evolution of methods of preparing salt for use in salt shakers to make the salt flow more freely in a moist atmosphere. The author located about a thousand United States patents isued in the last hundred years relating to various designs and mechanical features of salt shakers which are provided with all kinds of agitators, brush-type cleaners, extrusion means, pins in top perforations, scrapers and cutters, sifters and strainers. Brief descriptions of these patented salt shakers are given, and many patent drawings are reproduced to clarify the text. There is also included a discussion of methods used to overcome corrosion in salt shakers. That such a small although common article should receive so much attention by inventors and so little attention by historians seems surprising.

Containers for condiments, such as mustard and catsup, oil and vinegar, sirup and sugar, are also briefly touched upon.

Photographs of 550 glass salt shakers of many designs and shapes are included in this volume. A frontispiece in color illustrates 16 unusual art glass salt shakers. A name list of 830 glass salt shakers in pattern and art glass is included, which should be very helpful to a collector, and an appendix describes the techniques developed by the author for photographing his glass salt shakers.

JOSEPH ROSSMAN *

Offices in the Sky. By Earle Schultz and Walter Simmons, with a Foreword by Clarence B. Randall. Indianapolis: Bobbs-Merrill, 1959. Pp. 328, 20 plates. $6.00.

The considerable body of literature on the American skyscraper deals for the most part with the structural development, the methods of construction, and the architectural treatment of the tall office building. The present work, on the other hand, is concerned almost exclu-

* Mr. Rossman, a patent lawyer in Philadelphia, formerly edited the *Journal of the Patent Office Society.*

sively with the skyscraper as an economic institution, or more particularly, as an instrument in the administration of business organizations. In the authors' own words, "Our purpose is to relate the story of the office building as a tool of commerce and a prime factor in the growth of cities" (p. 17). And they might well have added, to relate the history of the National Association of Building Owners and Managers, for the book was prepared under the sponsorship of that organization, faithfully reflects its highly sectarian point of view, and records its activities in sometimes tedious detail.

Beginning with the Montauk Building in Chicago (1882), the authors present the growth and multiplication of skyscrapers, chiefly in Chicago and New York, in terms of the genesis of major projects, the costs, rents, and income associated with building investments, the development of mechanical and electrical utilities serving the comfort of tenants, and the problems of building ownership and management. The central theme is the equation of business with progress, which is celebrated throughout the book by lavish praise of the entrepreneurs whose wealth produced the forest of towers that characterizes Manhattan Island and the Loop area of Chicago. Within these limits the authors have written a useful and in places illuminating book, loaded with social and economic facts of a kind that the architectural historian seldom deals with. The work is particularly good in the presentation of well-defined phases of the skyscraper's history, such as the building boom of the 1920's, and specific projects, notably the Empire State Building and Rockefeller Center in New York and the Gateway project in Pittsburgh.

But *Offices in the Sky* has major defects which grow largely out of the narrow viewpoint of the building owner and manager. As a whole, it is fragmentary and disorganized, shifting illogically from the broad socio-economic narrative to detailed accounts of the year-to-year activities of the owners' association. There are no sources for the numerous quotations and no bibliography. The treatment of invention is sporadic and naively anecdotal: William Le Baron Jenney, for example, did not invent the steel-framed skyscraper because he saw his wife put a book on a bird cage. A century of experiment and construction in iron framing lay behind the achievement of the Chicago builders in the 1880's.

The most serious weaknesses arise from the authors' failure to comprehend the skyscraper in its full social and economic context and thus to assess its role in the totality of urban development. They appear to be unaware that excessive building of high office structures in the urban core for purely financial purposes has been a powerful factor in the demoralization of the city and the consequent abandonment of civic responsibility that accompanies the flight to the suburbs. Extreme over-inflation of land values, unmanageable traffic congestion, the deterioration of architecture into a form of public relations, the

destruction of well-designed and useful buildings to make way for the currently fashionable air-conditioned, curtain-walled boxes—these are dismissed either as non-existent problems or as minor costs in the onward march of "progress." The authors' hostility to genuine city planning and civic art, a bias which arises from identification of urban growth with narrow economic satisfactions, seems to this reviewer not only shallow but downright pernicious. The wealth of accurate factual detail in the book serves mainly to support the contention that building ownership and management must be identified with the total human need of the urban dweller and hence cannot be divorced from comprehensive urban planning.

CARL W. CONDIT *

British Shipping. By R. H. Thornton. New York: Cambridge University Press, 2nd ed., 1959. Pp. viii, 274. 25 Plates. $4.00.

Alfred Thayer Mahan, during the last century, made significant expositions regarding the elements of international power. His basic criteria dictated that a nation having a strong, balanced sea power must have: (a) a naval force capable of imposing national policy, (b) overseas bases to support such a naval force in any desired area, and (c) a merchant marine completely adequate to provide logistic support to the nation's industry and the overseas adventures of the naval-political forces. Great Britain has been the specific example of these requirements for centuries. Thornton takes his readers through the historical implications of these fundamental national philosophies without labeling them as such. He does, however, provide a systematic portrayal of the business of seaborne transportation—of the ships employed, the dockside activities, and the people that man the ships and handle the business at home and abroad. With more than usual wit he even provides a recognizable likeness of your Aunt Agatha's impact upon the day-to-day business of getting a modern liner cleared for sea.

British Shipping is not a thesis prepared after a cursory examination of the industry nor a literary research followed by editorialized interpretation. Thornton's knowledge is first-hand, and his analyses and evaluations are competent. The American reader will wish that the author possessed a better understanding of American philosophies and interests. While these provide no apology for some inept practices that have characterized the United States shipping industry, they do provide a background against which we must scan these practices. For example, Thornton should have been aware that while Great Britain

* Professor Condit, of Northwestern University, is the author of *The Rise of the Skyscraper* and of *American Building Art: Nineteenth Century*.

was aggressively moving into foreign markets with a comprehensive merchant marine, the United States, with a vast western hinterland, was putting its resources into intra-continental expansion. An explanation of this divisionary influence tempers Thornton's blunt condemnation of United States failure to exploit the ocean-going steamship.

Regardless, the reader will be impressed with the scope and organization of Thornton's work, which starts with a historical survey and leads accurately through the labyrinths of a giant enterprise of ships, people, and procedures which characterize the merchant marine. In one area this reader regrets that in the revision for this second edition the author felt constrained to eliminate some of the historical presentation of his earlier work. His uniquely comprehensive knowledge of the complete panorama of British seaborne commerce is worthy of full exploitation.

This is almost the A to Z of the art of overseas communication. A facet that has only recently come to being in the United States is not treated here. Many of the shore-side practices portrayed by Thornton are going to be modified by the advent of the container ship. These specially outfitted ships that provide a door-to-door shipping facility for the customer represent an innovation which will alleviate many of the problems of cargo segregation, routing, loading, and unloading. Assuredly Thornton will cover this seagoing "piggy-back" carrier in his next revision. Whether or not this service being unaugurated by Pan-American Steamship Co. and Grace Lines will have worldwide acceptance is difficult to predict. Traditional institutions do not readily accede to change; the fact that ships designed to handle the truck-van container are now being readied for the United States coastal trade augurs well for the future of this innovation.

Whether the reader is a novice traveller contemplating his first cruise at the exhuberant advertising of his travel agency, a prospective apprentice seaman, or a student of industrial technology, he will enjoy and benefit from the reading of this book. Thornton speaks not only with technical authority and experience, but with a native wit and imagination that lifts this book above the usual standard of technological portraits.

L. R. LAMPMAN *

* Rear Admiral L. R. Lampman (U. S. N., Ret.) is an executive of the Bendix Products Division, Bendix Corporation.

The Impact of Air Power: National Security and World Politics. Edited by Eugene M. Emme. Princeton, N. J.: D. Van Nostrand Company, Inc., 1959. Pp. xiv, 914. Index. 12 illustrations. $12.50.

"When Santos-Dumont became the first to get off the soil of Europe in a heavier-than-air craft in the fall of 1906, it was the British press magnate, Lord Northcliffe, who fumed, 'The news is not that man can fly, but that England is no longer an island.'" With these words Eugene M. Emme, the editor of *Impact of Air Power*, sets the tone of his book. Students of the history of technology will benefit from an exhaustive and authoritative treatment of the influence of aircraft and space vehicles on the military and political facts of life in the twentieth century. On the other hand, they will not find an account of the development of air and space vehicles in this compendium. They will learn much about how and why the flying machine revolutionized Great Britain's international position, but little on how Santos-Dumont and others perfected their flying machines. In sum, they will read much about the impact of air power on military tactics and world politics, but little on how man developed the technology of air power.

Emme, for many years Professor of International Politics at the Air University and currently with the National Aeronautics and Space Administration, has done a good job. While extensive literature exists in this field, Emme is the first to collect in one volume the best that has been written about air and space power. His selection of material has been outstanding. More than that, he has woven each selection into a well-organized and logical whole. In addition to presenting the views of eminent statesmen such as Churchill and Finletter, airmen such as Le May and Rickenbacker, soldiers such as Zhukov and Montgomery, and scholars such as Possony, McFarland, and Earle, he introduces each chapter with a searching and articulate preface, a cementing device here used extremely well (and a worthy example for other compilers of anthologies).

Almost all the selections point out the obvious fact that man wraps theories, doctrines, and strategies around technological innovations. Man ultimately formalizes ideas and deliberations into systems which, in large measure, determine the development and use of the technology. In the case of air and space vehicles, our very survival may well, *in extremis*, depend upon the effectiveness of these systems. The selections repeatedly indicate that the combination of jet aircraft and rockets with nuclear warheads enables an infinitely smaller force to wreak the same destruction as hundreds of World War II bombers armed with high explosives (TNT) and do it in a fraction of the time. In converting to these newer technologies, the United States has placed greater emphasis on the entire weapons system, including operational doctrine, support functions, and organization rather than on just the weapon itself.

As the U. S. developed modern weapons systems, it phased out its piston-driven high explosive air force. The Soviets also realized the inordinately greater destructive power of the newer weapons systems and plunged headlong into developing them. As a result, the Soviets have little choice but to deliver a nuclear attack via missiles and jet aircraft if they decide to cripple the United States by military action; for its part, the United States must retaliate in kind. Thus, strategies and doctrine, translated into systems, have in great measure so fashioned military technology that nuclear weaponry is not just a better way to attack a major nation's base of power, but now the only effective way.

On reading the selections one soon recognizes that the uneven rate of development in military technology has, to a large degree, colored the world situation. After all, has not the inability of defensive weaponry to keep pace with offensive weaponry since the atomic bomb brought the world to a "delicate balance of terror"? Unfortunately, it is infinitely more difficult and costly to devise instruments to protect than to destroy. Uneven rates of technological progress affect other areas of national survival outside the scope of Emme's volume. For example, methods for concealing underground atomic blasts are developing faster and at less cost than those for detecting such explosions. Emme's message, both as it pertains to air power and to other technologies of national security, thus should sober the reader. The knowledge of the stark realities of the air and space age should puncture illusions of a world rid of these instruments of death by some vague humanitarianism operating through international negotiation.

While it is difficult to single out a few of Emme's 118 fine selections, the readers of *Technology and Culture* would do well to pay special attention to Chapter XII: "Astronautics and the Future." In this chapter eminent men such as Berkner, Schriever, Boushey, Ehricke, Rickenbacker, and Shotwell glance into the future. Berkner effectively explodes the canard that communism stifles physical science, stating ". . . where science and communism conflict, the present Soviet leadership is willing to subordinate political doctrine to science—an extraordinary spectacle in a totalitarian state." Boushey touches on the import for the West of Soviet emphasis on science, remarking, "Today we find ourselves in not only an ICBM race with the Soviets, but in a race for the control of space itself." Rickenbacker paints a future world of abundant opportunities for a better life or for annihilation. In treating this same problem, Emme puts his finger on the heart of the matter when he says, "The significance of air power appears to be that lack of moral self-restraint by nations is root and branch of the question."

Anyone interested in the political and military effects of air power; anyone interested in the role of technology in the unfolding of history;

anyone interested in the most profound technological and moral dilemma of our age will profit from Emme's book. Through its pages, the reader can acquire an almost intimate acquaintanceship with those who help shape and interpret the history of the air and space age. Above all, the real beauty of this excellent compendium rests on the fact that the reader, by exposing himself to the hard core of so many contrasting opinions, can more knowingly pursue his own intellectual speculation.

R. SANDERS *

Studies in Company Finance: A Symposium on the Economic Analysis and Interpretation of British Company Accounts. Edited by Brian Tew and R. F. Henderson. (National Institute of Economic and Social Research, Economic and Social Studies, Vol. 17.) New York: Cambridge University Press, 1959. Pp. xiv, 301. 8 maps. 155 tables. $6.50.

This book is a statistical study and economic interpretation of the accounts of 2549 British companies engaged in trade and manufacturing, covering the years from 1949 to 1953, these being the first five years after the information became available as the result of the amended Companies Act of 1948. From the comparative balance sheets and the accounting analysis necessary to work out a statement of the sources and uses of funds for each company, the authors have derived what they call "indicators" of the changes and trends which they wished to study. Some of these indicators are dividends, capital issues, self-financing, bank and trade credit, and company size and growth. The first nine chapters of the book give an introduction and general observations about the finance and trends of the entire group of companies; chapters ten to fifteen deal with specific industries; and chapter sixteen contains a summary and the general conclusions of the study.

The authors found what seemed to be a decrease in the proportion of income distributed as dividends; apparently the increase in tax has been at the expense of dividends. Self-financing was an important source of capital. More than one quarter of the growth in net assets was financed by capital issues, fast-growing industries relying heavily on this source of capital funds. Little support was found for the common belief that bank credit is more important to the smaller than the large firm. The use of bank credit also varied widely between industries. Net trade credit (trade creditors less trade debtors) was another source of funds. While the data are not conclusive, the big firms seem

* Dr. Sanders, with the Industrial College of the Armed Forces, has written extensively on technology and politics.

to have fared better than the smaller ones. It was also found that a large number of the smaller firms ceased business because they were purchased by other companies, and, as would be expected, the larger firm made much more use of the capital market. Wide variations within the industrial group classifications were an important characteristic of the data.

In the chapters dealing with studies of particular industries, there may be information of interest to specialists in these fields. Brewing and textiles, although both classified as declining industries, present interesting contrasts. Other chapters are devoted to the building industry, building material and pottery, electrical goods, and retail distribution. Some of the general conclusions of the study were that there was little evidence of financial stringency in this period, that the capital market was clearly a vital source of funds especially for the larger firm, and that both bank and trade credit were other important sources.

Actually, this study says little about the important technological changes taking place in the various industries. Data taken from balance sheets and the funds statements would not generally reflect these technical improvements. The study does show that in the brewing industry the economies of large scale were important and that technical improvements in transportation had provided wider markets. There is also a limited discussion of the technological changes in the cotton industry. In this industry, however, there were no major innovations: ring spinning had been in the process of being introduced for mule spinning, and there had also been a change to automatic looms, but these are by no means new inventions. Prior to World War II, the cotton industry had suffered from intense foreign competition; after the war, it was recommended that the labor force be reduced and that the industry be re-equipped. The Labour Government accepted this, and in 1948 a subsidy was granted. From 1946 to 1954 something like 500,000 spindles were introduced.

This book is important because it represents a beginning study by British economists using accounting data for economic analysis. It is in every way comparable to the studies made in the United States by the National Bureau of Economic Research. Despite such older landmarks as J. M. Clark's *Economics of Overhead Cost* and Canning's *Economics of Accounting*, even in the United States the interest of the economist in statistical data based on accounting statements has not been of much importance. Relatively few economists are also trained accountants, and, of course, the difficulties of adjusting accounting data to fit economic concepts are great. Paton wrote his book on corporate profits as shown by audit reports in 1935. The book by Jacoby and Saulnier, *Business Finance and Banking* (National Bureau of Economic Research, 1947), is in many ways a comparable American study in its approach. It also contains an extended bibliography of published and unpublished

material available in this country. The authors of the study refer to the American book of Koch, *The Financing of the Large Corporation—1920-39*, which was published by the National Bureau of Economic Research in 1943.

A book of this kind will be read only by the economist or business man interested in this particular type of analysis. At the very beginning, these readers will be aware of some of the inherent limitations of the study. The authors are careful to point out these limitations and make it clear that they are trying to explore new areas in economic analysis. For example, one of the serious limitations is that the data used are now, on the average, nearly ten years old. The period was also one of post-war adjustment. Furthermore, as pointed out, the study covers only a fraction of all of the British companies. To prepare a satisfactory statement of application of funds, considerably more data are needed besides comparative balance sheets. Although not stressed in the study, some of the prepared material must have been approximations due to the lack of supplementary statements and journal entry analysis about write-offs, sales of fixed assets, refunding operations, etc. Despite these difficulties, the study is important as an attempt to expand economic analysis by using accounting data. It may prove to be an important beginning study that can be extended into the following years and would show important trends. American economists will also need similar studies of these years if worthwhile comparisons are to be made about company finance in this country and Great Britain.

Technology is certain to become of increasing importance to economists. They have, of course, long been interested in such problems as labor displacement due to technological change. Technology is now an important factor in studying the problem of economic growth, planning production to take care of the great upsurge in population, and in our attempt to work out programs to assist undeveloped countries. This book suggests another new field in the study of technical change and its effect on corporate policies and finance.

LAWRENCE R. CHENAULT *

Industrialization in the Middle East. By Kurt Grunwald and Joachim O. Ronall. New York: Council for Middle Eastern Affairs Press, 1960. Pp. xx, 394. $7.00.

The Middle East, for the purposes of this study is taken to comprise the Arabic-speaking countries as far to the west as Libya, as well as Israel, Turkey, Cyprus, Iran, Sudan, Afghanistan, and Ethiopia. By

* Dr. Chenault is Chairman of the Department of Economics at Hunter College.

any standards of evaluation the Middle East forms an underdeveloped area. Compared with the accepted developed areas of Europe or the United States and Canada, these Eastern countries rate very poorly in all important indices: literacy is $\frac{4}{11}$ths, life expectancy nearly half, gross national product per capita $\frac{1}{12}$th, and electric power (rated on the basis of KWH per year) as low as $\frac{1}{28}$th of the comparable items for developed areas.

With the exception of oil, found in abundance in this region but mostly used outside these countries, the Middle East has few natural resources. According to this survey, poverty, endemic disease, high mortality, and gross illiteracy form the pattern of life for the vast majority of the 140 million inhabitants representing this five per cent of the world's estimated population and occuping nine per cent of the total surface of the earth.

By and large agriculture still forms the basis of Middle Eastern Society, and in most countries of this region it is the major contributor to the national product. Archaeologically the Middle East was once very densely populated, having a number of reservoirs, canals, and irrigation works—the ruins of which can be found in Jordan, Syria, Lebanon, Israel, and Iraq.

Just as the Industrial Revolution in Britain was preceded by innovations in communications, industrialization in the Middle East began during the early nineteenth century when regular sea connections were introduced to carry the products of the Western cities like London, Marseilles, and Trieste to Lebanon and Syria. The two World Wars stimulated communications, and the Middle East opened its doors to channelized western influences of telephone, telegraph, and radio communications, as well as through direct links of railroad, motor, and air traffic. Western manners, social customs, and education slowly began to infiltrate the East, and diversified, intertwined, and, at times, contradictory tendencies began to emerge as the future pattern of these nations. The traditional ewers and jugs were slowly replaced by enamelware or kerosene cans, and the strikingly attractive local jewelry gave way to glass beads, indicating the decay of local industries and the disappearance of indigenous talent and craftmanship.

These facets of the economic growth of Middle Eastern nations are critically evaluated in this volume. A poetical-cum-philosophical introduction, entitled "As They See It," ushers the reader into the mystifying drama of Eastern economics. Here detached paragraphic quotations by distinguished savants are given under such sub-heads as the Pessimist, the Optimist, the Educator, the Sociologist, the Statesman, the Historian, and rounded off at the end by the Economist.

The main study which follows this introduction is split in two sections. The first is entitled "Issues and Problems" and the second "Industrialization by Countries." In the former the authors cover generalized topics on population, labor, productivity, urbanization,

natural resources with emphasis on oil production, transport and communication, and monetary, financial, and banking requirements.

The second section expatiates on the industrial problems and outlook of the Middle East by country, covering Afghanistan, Cyprus, Egypt, Ethiopia, Iran, Iraq, Israel and Palestine, Jordan, Lebanon and Syria (Levant States), Sudan, Turkey, Saudi Arabia, Kuwait, Yemen, and Libya.

Each country is critically examined with reference to its various technological phases, such as electric power, mining, and agriculture, and emphasis is laid on its specialities. The coverage is not uniform and varies from a mere four to six pages for Sudan, Jordan, and Afghanistan to over 25 pages each for Iran, Palestine, Israel, the Levant States, and Turkey. This is inevitable, for the states differ in their potential wealth, forms of trade, and economic levels and therefore must be treated individually on their merits.

As an example, it is interesting to consider the case of Iran, to which some 28 pages are devoted. Data available up to 1958 have been included in this survey, but conditions since then have not come up to expectations. Present per capita income is estimated at $120 a year, and with careful planning and marshalling of various resources Iran could double its income in five years. Iran's submerged millions could be resettled on new virgin land, rural cooperatives could be formed, and small scale industries set up; yet an archaic political setup has thwarted land reforms and community development. There is unfortunately no endeavor in this direction in spite of the fact that Iran boasts of a $1,100,000,000 Seven-Year Plan covering 1955-1962. As in India, this outlay does not take into account all development expenditure; for instance, the proposed steel plant at Ahwaz is outside the scope of this Plan. This results in unsound economic investment and financial imbalance. Industrialization thus loses its real significance and forms a mere "show-piece" of investment. On the other hand, with booming oil revenues, Iran is on a spending spree, the biggest investment being in the construction industry. In the last two years, Teheran alone has invested nearly $300,000,000 in construction and is choking the free land with swanky multi-storeyed offices and apartment houses—items little suited to the country's economic situation.

Taken as a whole, this volume is a scintillating survey of the contemporary state of industrialization in the world's largest underdeveloped bloc. What is clearly visible from this study is that the Middle East cannot conglomerate into an overall federation because the economies of the various countries do not supplement each other. Unfortunately, their products are largely identical, and so is their economic structure. This is revealed by the trade figures: in 1937 the intra-regional trade of Middle Eastern nations amounted to only 6.6 per cent of their total foreign trade. In 1957 the volume had doubled but was still not decisive in the total volume of their international trade, with

the exception of Lebanon and Jordan. It has become clear that a common interest cannot be evoked, and integration lacks strength. As suggested by the authors, a Middle Eastern Common Market might serve the purpose of a pacifier, but its economic value would be questionable. Cooperation in development projects appears more practical, especially if these are well defined and limited in scope, such as pest control, transfer of population, and power and irrigation across international borders.

The study ends with an Epilogue summarizing the salient features and outlining the potentialities and limitations of industrialization in the Middle East. An exhaustive bibliography gives in a nutshell the vast array of literature now available for the study of problems of underdeveloped areas. The book should have an appeal to the Western Powers with whom the Eastern nations are slowly being linked; it should evoke even greater interest in India, which during the last few years has been making rapid strides in industrialization in spite of her limited financial resources and general underdevelopment.

Both authors are European economists of repute; they were invited by the Council for Middle Eastern Affairs to prepare this study of the actual facts of industrialization in that area. They have done their job well and have presented the reader with facts and figures, exhaustive statistical data, and maps of the industrial wherewithal of the countries comprising the Middle East.

S. K. GHASWALA *

Der Ingenieur und Seine Aufgaben in Neuen Wirtschaftsraumen. Dusseldorf: VDI-Verlag GMBH, 1959. Pp. 202. 9,80 DM.

In June 1959 the Verein Deutsche Ingenieure (Association of German Engineers) held a symposium at Aachen, Western Germany, on the theme " The Engineer and His Problems in New Economic Areas." This volume contains the text of the papers presented at this meeting:

H. Friebe, " Tasks of the Engineers in the Service of World Organization ";
G. Henle, " New Economic Areas and the Problems of Their Development ";
A. Müller-Armack, " The European Economic Area ";
G. Wirsing, " Fundamental Problems of Underdeveloped Countries ";
A. Bergsträsser, " Tasks of Technology in the Present Stage of Civilization ";
P. Leinweber, " The International Cooperation of Engineers at Work ";

* Mr. Ghaswala, of Bombay, India, is a Consulting Engineer and Technical Editor of *The Indian and Eastern Engineer.*

W. R. Batorffy, "Code of Ethics and Practical Successful Results of Engineers Abroad";
B. Plettner, "Experiences in the Service of a Large Firm Abroad";
H. Knipping, "Technical and Personal Problems during the Execution of Large Projects in Underdeveloped Countries";
A. Rucker, "The Possibilities of Special Training for Work Abroad";
A. F. Flender, "Educational Tasks for Schools and Industry."

This table of contents is sufficient proof that these essays have little to contribute to the history of technology, being mainly concerned with the present or the future. Many of them contain data on the clash and conflict between native skill and foreign technology and on the difficult struggle in most underdeveloped countries to achieve in one generation what centuries of European technical evolution have attained. Having worked in such countries, I miss the realization of the excellence and efficiency of native techniques and tools in several fields, a point that should be taken into account when working overseas. Having watched several contests between skilled Chinese wood-cutters armed with good American steel axes and Dajak tribesmen with stone axes attached to bamboo-handles, in which the latter invariably won, cutting down tropical trees in 25 per cent less time, I have been much impressed by such primitive techniques and tools. The engineer working abroad should reckon on such tools and techniques unless he can count on the full gamut of modern equipment in the country where he is working. In India and China today such native techniques and tools are used on a large scale and with great success during the intermediate stages of transformation of the indigenous technology into modern engineering. Hence such tools and techniques deserve more study and application then is given in the essays of this small book, which, however, is well worth reading.

R. J. Forbes *

The Atom and the Energy Revolution. By Norman Lansdell. New York: Philosophical Library, 1958. Pp. 200. Illustrations. $6.00.

This is a book intended for the general reader who wishes to have some understanding of the overall energy situation and the manner in which the development of nuclear energy may be expected to influence the world picture. Mr. Lansdell introduces his work with a brief discussion of world energy resources and the demand for the conventional fuels; this is followed by a consideration of the newer sources of energy, chiefly solar energy, electro-chemical generation of electricity, and direct conversion of radiation into electric current.

* Apart from his historical research and writing, Dr. Forbes served for many years with the Royal Dutch-Shell Corporation.

The major part of the book comprises a discussion of some of the technical aspects involved in obtaining nuclear energy, together with a review of the more important materials upon which this new industry will depend. In addition, there is a fairly detailed treatment of the major uses of atomic energy, the latest developments in the major countries, and some of the international organizations that have come into being due to the advent of another major source of energy that will have to be fitted into the overall framework of energy supply and demand.

Unfortunately, there is an almost complete dearth of definitive literature by which to measure Mr. Lansdell's contribution to this field. The only work that comes to mind is Palmer Putnam's *Energy in the Future* (1954), which concentrated on the future energy requirements of the world and the ability of fossil fuels to supply these over the next hundred years. Putnam assembled an imposing array of figures to show that fossil fuel reserves would be depleted in a hundred years or less—a mere moment in geological time; Lansdell, dealing with this subject, makes several references to the depletion of fossil fuels but offers nothing conclusive in the way of statistical evidence to support his position.

Although the book is entitled *The Atom and the Energy Revolution*, Mr. Lansdell concludes that he sees no important future for nuclear energy in the realm of ship propulsion, steam raising, process heat, or land transportation. This leaves only electricity generation as a field for the use of nuclear energy.

The advent of power from the atom introduces still another method which characterizes the significant change that is taking place in the energy economy of the major industrial countries, namely, the trend to consume more and more of our requirements for energy in the form of electricity. This, in the opinion of the reviewer although it is not pointed out in this work, constitutes the energy revolution that will take place in the next twenty years.

Mr. Lansdell writes further about a world authority which would be concerned not only with atomic energy but also with the exploitation of all forms of energy. Perhaps one day the International Atomic Energy Agency can assume responsibility for developments of this nature. In the meantime, ideas concerning such control must remain in the realm of speculation.

In conclusion, the theory is advanced that if nuclear energy from fusion is accomplished, the demand for uranium will disappear. This idea has been propounded in several other reports relating to the future of nuclear energy. It is, in the opinion of the reviewer, a conclusion that not only is not substantiated but also one that can do a great deal of harm to an international industry in which many hundreds of millions of dollars have been invested, i. e., the uranium industry. The eventual accomplishment of energy from fusion will still leave ample

room for a world wide uranium industry of significant proportions—possibly restricted to the fields of transportation and small electricity and steam raising plants.

B. C. THOMPSON *

Atomic Energy in the Soviet Union. By Arnold Kramish. Stanford, Calif.: Stanford University Press, 1959 (Rand Series); London: Oxford University Press, 1960. Pp. x, 232. $4.75.

Arnold Kramish, a member of the research staff of the Rand Corporation, has not written the "definitive work" on the history of nuclear physics in the Soviet Union, but he has written the best book available on the subject. Until that improbable day when the Soviet Union opens archives and convenes more freely about its activities in the nuclear field, scholars will find it difficult to write a more informative study. Kramish has had to piece together a narrative from scraps of information and fill in gaps with informed speculation (the author does make it quite clear when information ends and speculative reasoning begins).

According to the Kramish narrative the Soviet had scientists in the '20's who had worked in nuclear physics (Peter Kapitsa, for example), but funds were limited as the state was disinterested. Early in the '30's, however, more funds became available—possibly due to the support given by politician and theoretician N. I. Bukharin—and by 1940 the scientists of the Soviet Union had equipment and knowledge comparable to that of the great powers.

Although the Soviet was abreast of the other powers when the war began, a turning point came when the British and Americans decided to support an atomic military program while the Russians virtually abandoned their support of nuclear physics in 1941 with the German invasion. The Russians may have withdrawn support because of military expediency or because they foresaw only industrial applications.

The author does not emphasize the role of espionage. He believes it likely that reports from the agents were no more sanguine than the prognostications of many of those involved in the Manhattan Project until the bomb exploded. In any event, the collaboration with the Soviet of scientists and non-scientists involved in that project gave the Russians unofficial observers in an allied effort from which the Soviet was excluded.

After the bomb exploded the Soviet had only a brief time to press

* An economist and sociologist, Mr. Thompson's specialty is the analysis of future energy requirements in terms of technological change. He was formerly with the Soconoy-Mobil Oil Co.

for cooperation with the West with regard to the bomb. The Soviet Union did not seek this cooperation but decided to go it alone. By 1947 the Russians had built their first reactor (remarkably similar to an earlier U. S. reactor) and believed the U. S. monopoly would be short-lived. The nuclear program abandoned when the war began now had a high priority, and Russian diplomacy confidently followed a hard line with regard to international control of atomic energy.

Russian expectations were not disappointed, for their scientists and engineers produced an atomic explosion in 1949 and a hydrogen device in 1953. The nuclear program was flourishing under the aegis of the Academy of Science and with government support under the five-year programs. Having exploded a number of excessively "dirty" bombs and contributed mightily to a belt of long-lived fission products projecting around the earth roughly at the 45th parallel, the Soviet then began to emphasize its interest in peaceful uses of atomic energy and to call for test bans.

Kramish believes that Russians in the '50's with their well-publicized pioneer atomic-powered electrical plants, their atomic-powered ice-breakers, the bold plans for future peaceful applications, and an acute sense for propaganda have generated an atmosphere of progress and bold speculation among the Russian scientists, engineers, and population in general. He believes that the Western powers might well ponder their own policy of classification and secrecy in the light of the propaganda value of publicity both at home and abroad.

There are undoubtedly many errors of fact in this study that only the Russians could correct. Despite the reluctance to accept the conclusions of a study necessarily based on insufficient evidence, the reader will find it difficult to discount one general conclusion—technology and science can flourish in a communist and authoritarian state. Kramish is to be commended for supplying a historical narrative that helps to explain this phenomenon.

THOMAS P. HUGHES *

Classical Mathematics: A Concise History of the Classical Era in Mathematics. By Joseph Ehrenfried Hofmann. Translated by Henrietta O. Midonick. New York: Philosophical Library, 1959. Pp. 159. $4.75.

This book is a translation of the second and third volumes of Hofmann's *Geschichte der Mathematik* which cover the period "von Fermat . . . bis zur französischen Revolution." It is unfortunate that

* Dr. Hughes, Associate Professor of History at Washington and Lee University, specializes in the history of Russia as well as in the history of technology.

the English title is not so explicit as to the period which is treated since one might well expect the work of Gauss, among others, to be included in a study of classical mathematics.

The original work, published in 1957, is a respected addition to the literature of the history of mathematics and presents a good deal of material in compact, readable form. It is, of course, much less detailed than Cantor's monumental *Vorlesungen über Geschichte der Mathematik*, but at the same time Hofmann enters into considerable technical detail, unlike the more popular works of Bell. The book, in the original or in translation, is not for a reader without considerable mathematical sophistication.

At this point I feel that the prospective reader is entitled to know that the translation is awkward and occasionally does not quite convey the sense of the original. For example, "DESCARTES stammt aus altem normannischem Adel; sein Vater JOACHIM DESCARTES (+ 1640) war Rat am bretonischen Parlament in Rennes" is translated as "Descartes came of an old Norman family of nobility. His father, Joachim Descartes (d. 1640) was a councillor in the Breton parliament at Rennes." Even more important, from a scholarly point of view, is the fact that the translation does not include the excellent documentation of the original.

Readers of this journal will be concerned, undoubtedly, with the manner in which Hofmann relates the history of mathematics to other spheres of human activity. There is a slight discussion of the philosophical activities of various mathematicians and of the interaction between the development of mathematics and philosophy, but little is said of the vast mutual influence of physics and mathematics upon each other, and nothing is related about the effects of an expanding technology on the mathematics of the seventeenth and eighteenth centuries. *Classical Mathematics* may be characterized as an inward looking history of mathematics in the sense that the development of mathematics during the period is portrayed as an essentially isolated phenomenon. This may not lessen the value of the book to a reader interested in tracing a line of mathematical thought, but the reader with less purely mathematical interests may soon lose interest. Such a person might profitably read Struik's very brief *A Concise History of Mathematics* (New York, 1948), which is well documented and may be read by a person with lesser mathematical attainments than those needed by a reader of Hofmann's work.

It seems to me that Hofmann is less than judicious in ascribing the discovery (or invention) of the calculus ". . . exclusively to the credit of G. W. Leibniz . . ." We must remember that the original controversies over priority in the discovery between Newton and Leibniz (and the many followers of both men) centered on the ideas of the calculus; Hofmann gives credit to Leibniz because of the latter's vastly superior symbolism. There is little question but that Leibniz's notation

was a stroke of genius that helped to make possible the brilliant advances made by continental mathematicians and that Newton's notation slowed the progress of English mathematics, but most current opinion agrees that the discovery of the central ideas of the calculus was made independently by both men. For the aesthetically inclined, the question is a fascinating one concerning the relation of form to content.

On the whole, I should think that a mathematically mature person who has some prior knowledge of the history of mathematics would find the present translation of Hofmann's work of value in understanding the development of mathematical thought during the seventeenth and eighteenth centuries; others beware.

MARK LEVINSON *

The Scientific Revolution: Challenge and Promise. A symposium, edited by Gerald W. Elbers and Paul Duncan. Washington, D. C.: Public Affairs Press, 1959. Pp. viii, 280. $6.00.

In the winter of 1958 the President's Committee on Scientists and Engineers, assisted by the William Benton Foundation, sponsored a conference at Yale on "America's Human Resources to Meet the Scientific Challenge." The volume under review contains thirty-two papers by leading participants in that conference, organized under the following somewhat ambiguous headings:

PART ONE

I. America in an Age of Science
II. The Soviet Challenge
III. Developing an Adequate Science Program
IV. Public Understanding of the Scientist

PART TWO

V. Forty Million Growing Minds
VI. The Coming Crisis on Campus
VII. The Education and Use of Superior Talent

As this outline suggests, there appears to have been general agreement that (a) the rapid advances in science and technology confront us with a multiplicity of problems, and (b) the basic solution to these problems is to be found in more and better education. No one is likely to dispute either of these premises.

* Mr. Levinson, Assistant Professor of Mechanical Engineering at Oregon State College, teaches and does research in the area of applied mechanics. He has a long standing interest in the interactions of mathematics, science, and technology.

While the usual disclaimers are duly entered, the sense of almost frantic urgency that envelops this book leaves little doubt that Sputnik was here. It was in the excitement and tension of this period that several ill-considered proposals for crash programs in education were made. Note should be taken of the date, however, for there is considerable evidence that since 1958 scientists, educators, and public observers alike have had soberer second thoughts about the nature of the challenge and the methods for meeting it.

Even in 1958 some of the participants kept their heads and took the long view. There are articles by Eric Walker and Harold Tuve that do come to grips with ideas for improving the quality of education for both scientists and non-scientists. There is a very telling plea by Representative Edith Green of Oregon for a better understanding by specialists and experts of the realities of the legislative process. There is a penetrating article by Margaret Mead on "The Climate of Opinion Necessary for Science." And, somewhat lost here, I am afraid, there is an unusually shrewd analysis of the Soviet and American aid programs for underdeveloped nations by W. W. Rostow.

These and a handful of other papers make *The Scientific Revolution* a volume which readers of this journal cannot ignore. Much of what is said is painfully platitudinous; some of it is already dated; but some of it is worth preserving. There is no carefully developed argument that compels one to brave the clichés from cover to cover. Most of the articles are self-contained so that one may pick and choose without loss of continuity. This is the procedure that I recommend.

GEORGE A. GULLETTE *

Creativity and Its Cultivation. Edited by Harold H. Anderson. New York: Harper & Brothers, 1959. Pp. xiii, 293. $5.00.

This volume presents the special views of fifteen students on various aspects of creativity. The published form of the book evolved from addresses delivered at an interdisciplinary symposium held at Michigan State University. The book is edited by Dr. Harold H. Anderson who also contributes a chapter on "Creativity as Personality Development" and a summary statement on "Creativity in Perspective."

It is difficult to write a brief and informative review of this book for each author has written a complete essay on that aspect of creativity which he or she considers most important. Possibly the scope

* Dr. Gullette is head of the Department of Social Studies at North Carolina State College. He was Director of the Humanistic-Social Research Project of the American Society for Engineering Education which produced the volume *General Education in Engineering.*

of the volume can best be given by selecting a sentence or two from each presentation. These excerpts should not, of course, be considered as presenting the full thesis of any of the writers who have contributed to the book.

In Chapter I, "Scientific Creativity," Henry Eyring says that "Society will succeed in continuing its creative advance because the alternative to this is irreversible disaster to everyone."

Edmund W. Sinnott in Chapter II, "The Creativeness of Life," relates that "one of the most dramatic cases of regeneration has been found in certain sponges, where the whole body may be completely broken down into its constituent cells by being gently squeezed through a fine-meshed piece of cloth. These cells, if they have access to each other, will before long begin to fuse into small and then into larger groups, and finally will organize themselves again into the body of a sponge." On a later page he wisely adds: "What, then, may we conclude as to the biological basis of creativity? Simply this, I think: that life itself is the creative process by virtue of its organizing, pattern-forming, questing quality, its most distinctive character."

In the next chapter, "An Architect's Views on Creativity," Alden B. Dow states, "Here we are interested in the constructive side of creativeness, and, after all these words, I wonder if it cannot be reduced to just one word—care."

Erich Fromm ends his chapter on "The Creative Attitude" by saying, "Let me say again that creativity in this sense does not refer to a quality which particularly gifted persons or artists could achieve, but to an attitude which every human being should and can achieve. Education for creativity is nothing short of education for living."

In the chapter, "Toward a Theory of Creativity," by Rollo May the creative process is defined as "the emergence in action of a novel relational product, growing out of the uniqueness of the individual on the one hand, and the materials, events, people, or circumstances of his life on the other."

Abraham H. Maslow in Chapter VII, "Creativity in Self-Actualizing People," concludes that "all of these developments can, I think, be summarized as an increased stress on the role of integration (or self-consistency, unity, wholeness) in the theory of creativeness. Resolving a dichotomy into a higher, more inclusive unity amounts to healing a split in the person and making him more unified."

In discussing "Vicissitudes of Creativity," Henry A. Murray says that "the creative process never flies like an arrow or a bullet to a target, but proceeds toward an unknown destination by countless digressions and irrelevancies, decompositions and altered recompositions, many of which take place outside the reach of consciousness during periods of incubation. Consequently, the creative process takes time, its own time, maybe a lifetime, and very often death arrives before the fulfillment of its hope."

Harold H. Anderson in his chapter on "Creativity as Personality Development" states that "creativity as personality development is not only a product of openness in human relating; it is a further opening to higher levels of harmony in the universe."

In Chapter X, "Traits of Creativity," J. P. Guilford points out that "awareness of the nature of the traits of creativity should provide a much better basis than formerly for systematic methods of education in this important area."

Ernest R. Hilgard scrutinizes the topic of "Creativity and Problem-solving": "I wish to call attention to some immature or childlike qualities manifested among these creative people. Among those qualities I would list: (1) dependency upon others, with refusal to accept (or carry out) the ordinary social responsibilities of adult life; (2) defiance of authority or convention; (3) a sense of omnipotence, or what Gough has called sense of destiny; and (4) gullibility, or uncritical acceptance in some intellectual sphere, no matter how critical in others. Dependency, defiance, omnipotence, and gullibility are common enough in childhood so that it is not unfair, if creative people have these qualities, to describe them as in some respects immature."

In his chapter on "Creativity in Education," George D. Stoddard states that "to be creative, in short, is to be unpredictable; it is to be decidedly suspect in the world of affairs. The creative aspect of life is rightly viewed as action. Never simply contemplative, the creative act at its highest brings about notable differences in things, thoughts, works of art, and social structures."

Harold D. Lasswell expresses the view that "creativity is the disposition to make and to recognize valuable innovations," in his chapter on "The Social Setting of Creativity."

In Chapter XIV, "Creativity in Cross-cultural Perspective," Margaret Mead says that "in drawing upon anthropological materials from many different primitive cultures, we are seeking not for models but for relationships between the forms provided by a culture and the creativity of the individuals within the culture, upon which statements of regularities may be based." She later stresses that "above all, we need research to show the difference between the sense of discovery or of creativity and the quality of the discovery or the creativity."

Harold H. Anderson writes the final chapter, "Creativity in Perspective." He emphasizes the social need for creativity. He says, "Most of our authors have mentioned a social as well as individual need for creativity. These authors were not perfunctory in their citation of this problem. Rather have they presented the need for creativity as a national crisis, a desperate situation for the military forces, for industrial leadership, for humanitarian living."

Real research in pure science and inventions in technology are, of course, typical examples of human creativity. Most of the chapters in this book offer insights into these important related processes. How-

ever, although the specific examples of scientific and technological creativity that are given are interesting, the book's emphasis upon a psychological explanation of all forms of creativity, artistic as well as scientific, is even more significant.

It is hard to think of any person engaged in constructive active modern life who can afford not to think about human creativity. All such people, therefore, can, in some measure, profit by reading this volume. It used to be said that " it takes a genius to understand genius." Those who read this book should remember that it may likewise be true that one must be creative in order to understand creativity.

LEONARD CARMICHAEL *

* A noted psychologist, Dr. Carmichael is Secretary of the Smithsonian Institution.

Communications

To the Editor of *Technology and Culture:*

The controversy entitled "Inventing and Patenting" might have profited by a discussion on the part of an engineer who had had quite a few patents to his credit and was familiar with the state of the art in his particular speciality. While such a view might understandably be considered limited in scope, it might also indicate that it is extremely difficult to justify an overall statistical measure of the type proposed by Dr. S. C. Gilfillan. For my part, one of my earliest engineering assignments was an assistant to the patent counsel of a large manufacturing organization, and I would sharply disagree with some of the criteria that Dr. Gilfillan proposes for measuring the rate of invention. As a former engineering periodical editor and one who has just gone over about the last thirty volumes of ASME Transactions, I can see no correlation whatever between inventive effort and number of technical articles published.

In the conventional steam power industry probably the outstanding development of the past decade has been the adoption of supercritical pressure for large central stations. To date five power plants have been or are in the process of construction for operation under steam conditions considerably in excess of the average central station and with the highest thermal efficiencies ever achieved by the power industry. Yet the beginnings of this process would date back to Jakob Perkins, who emigrated from America to Europe in the early nineteenth century. The basic patents for the steam generators being used could be traced also to Europe in the 1920's. Thus if invention and patents were the sole criterion to industrial progress, the accomplishments of the first large-scale supercritical pressure power plant would not even register in the statistics. In point of fact—and I have not checked this but have reason to believe it to be reasonably accurate—there probably were some thirty to fifty patents issued on very minor details of boiler, turbine, and auxiliary design used in these power plants.

What I am trying to establish is that the criterion of technological progress in this instance was neither invention nor number of patents issued. The development of supercritical pressure power plants just could not take place until the art and science of metallurgy had advanced to the point where materials were available to match the bold concepts of more than a century ago, to the known thermodynamic advantages of the supercritical pressure cycle. I am afraid in this whole controversy the very basic role of engineering *development* is being overlooked in the preoccupation with the place of the inventor and the number of patents.

GLENN R. FRYLING, Editor
Combustion Engineering

To the Editor of *Technology and Culture:*

The article by S. G. Gilfillan on the rise of American inventing and decline of patenting was interesting reading.

Some corrections and additions should however be made in the interest of obtaining a complete and true story.

The constitutional provision reads: "The congress shall have power —to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their writings and discoveries."

Note that there is no mention of corporations in this provision.

Corporations as-a-way-of-life did not begin to arise in America until after the Civil War.

With the rise of the corporations came a new being into existence, namely, the employee-inventor.

For considerable time it was legally doubtful if an inventor could assign his inventions yet to be born, i. e., his inventions "in futuro."

Ultimately the courts ruled such a contract was valid.

Today a research chemist upon graduation from college obtains a corporation job and may be paid for a whole year or more before he makes his first invention for the corporation employer. Under the contract he must assign his invention to the corporation. But the corporation need not file patent application papers on its inventions.

Also, while about 60 to 70 per cent of the patents issuing from the U. S. Patent Office carry a notation of assignment thereon, it is an error to conclude that only this percentage of inventions are corporation-owned. Actually many corporations as a matter of policy do not file the assignment papers until after the patent issues. And some may never file the assignment papers. It is not a criminal offense not to record assignments.

What has actually happened over the years is that the corporation corpus is in fact the inventor. And in countries such as England and others the corporations often take out patents in their name without even mention of a human inventor.

Clearly much inventing is now done in reality by the corporations through captive inventors, but not all the inventions of such captives are filed for patents.

Moreover, a large share of inventive intelligence is presently engaged in military inventions, and the patents on these, even if in the name of contracting corporation of the government, are held in secret.

In any event the decline in patenting, which is an expensive legal procedure, should be attributed to the modern corporations for whom the modern inventors in very large measure work.

Frank Makara, Ph. D.
Registered Patent Attorney
New York, N. Y.

To the Editor of *Technology and Culture:*

Dr. Makara's observations are mostly familiar facts. I would disagree only with his statements that he adds necessary corrections to my article, and that "the decline of patenting . . . should be attributed to the modern corporations." It is a world-wide phenomenon and must be traced to many causes: to bigness of business, rather than to its corporate organization; to monopoly, although effort to achieve monopoly is one incentive to patenting; to courts' destruction of patents, often for reasons of monopoly; to governmental inventing above all; probably to collegiate education and the more social, friendly spirit of modern business leaders; and to improvement of the patent bar and of general education, reducing the patenting of silly inventions. Certainly the quality of inventions patented has much improved, as the percentage patented has declined. And there are doubtless still other causes.

Mr. Fryling's experience in modern steam generation is welcome, but his objections are based on misconceptions of my claims. (1) My article relates to invention and invention-oriented research as a national total varying over time, and makes no claim to measure or explain particular industries, which have doubtless differed. (2) The definition of such invention, etc., on which the article is based, is not Patent Law's definition, but includes development and every smallest improvement, from those that took five minutes time of one employed professional to the "great inventions" that took five million hours. And each invention or improvement is duly if roughly weighted. The improvements in accessory lines, like metallurgy helping steam boilers, are included in those national totals. (3) It is not I but Professor Schmookler and Mr. Kunik who think that patents are of some use for measuring the long-time trend of invention. (4) Mr. Fryling's statement "I can see no correlation whatever between inventive effort and number of technical articles published" either relates to the work of one individual, which I never considered, or it is sheer absurdity, or it has some third meaning. This last hypothesis is the most likely. Perhaps Mr. Fryling's meaning is: "I am so impressed by the qualitative changes summed up in the great inventions, and so disgusted with ordinary statistics of patents, inventions, etc., that I am unable to think statistically about this matter." (5) Yet Mr. Fryling apparently feels that the nub, the chief reality of invention lies in laborious development of details. This is exactly my own idea, and my statistics are based on it. (6) The Abstracts I have called indices of inventive output rather than of effort or input. Of course the two are closely correlated, only input seems to have risen still faster than output.

S. Colum Gilfillan, Ph. D.
Chicago, Ill.

Organizational Note

The following changes and additions have been made in the program of the meeting of the Society for the History of Technology, to be held in New York City (Belmont Plaza Hotel) on December 27-30:

A two-part symposium on "Patents and the Advancement of Knowledge," which the Society is co-sponsoring with Section L of the American Association for the Advancement of Science, will take place on Friday, December 30 in the Crystal Room A & B of the Belmont Plaza Hotel. The first session will take place at 9:00 a. m. and will include papers by Jacob Rabinow (Rabinow Engineering Co., Washington, D. C.), Richard P. McGrail (Executive Vice-President, American Cancer Society), and Johan Bjorksten (President-Elect, American Institute of Chemists). J. William Hinkley (President, Research Corporation) will preside at the morning session.

The afternoon session of the Patent symposium will take place at 2:00 p. m., also in the Crystal Room of the Belmont Plaza. Fritz Machlup (Professor of Economics and International Finance, Princeton University), Berj Hagopian (Transval Electronics Corp., El Segundo, Calif.), and Charles C. Price (Chairman, Department of Chemistry, University of Pennsylvania) will give papers. Chancellor Robert L. Johnson of Temple University will preside at this session, and Rudolph J. Bannow (President, National Association of Manufacturers) will introduce the guest of honor: Commissioner Robert C. Watson of the United States Patent Office.

Dr. Harry Woolf will deliver the vice-presidential address of Section L at 11:00 a. m. Friday, December 30, in the Belmont Plaza Crystal Room. His topic will be "The Evils of Secrecy."

The Society is also presenting a joint panel with Section B (Physics) and Section M (Engineering) of the American Association for the Advancement of Science on Friday, December 30, at the Biltmore Hotel, Room A. Topic of this panel, which will meet at 9:00 a. m. and 2:00 p. m., is "The Place of Nuclear Engineering in the University Curriculum."

The program on Automation, featuring papers by John Diebold and James R. Bright, will be held in the Basildon Room of the Waldorf-Astoria Hotel, instead of the Baroque Room of the Belmont-Plaza Hotel, as originally announced. That program will be at 2:00 p. m. on Thursday, December 29.